# STUDIES ON INDIAN DECAPODS

**THESIS**

SUBMITTED TO THE

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IN

**ZOOLOGY**

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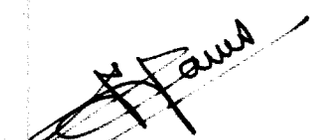
This is to certify that the thesis is a bonafide record of work carried out by Mr. K.M. Thomas under my supervision and that no part thereof has been presented before for any other degree.



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# PREFACE

There has been no comprehensive work on the taxonomy of Indian Penaeidea and Paguridea since the publication of Alcock's catalogues of these crustaceans in the Indian Museum. Although Kemp has dealt with many Caridea in his papers in the Records of Indian Museum, he has left out the commercially important penaeid prawns. But recently George (1969), has given accounts of the taxonomy of commercially important prawns. The various aspects of biology of penaeid prawns of commercial importance have been worked out by various authors. Mohamed (1969), Rao (1969) and Kunju (1969) have given details on the biological aspects of the most important species while Rao et al (1969), Ramamurthy et al (1969) and Banerji (1969) have dealt with the fishing grounds, methods and the resources of these prawns. Practically no work has been done on the green prawn Penaeus semisulcatus mainly due to the non-availability of the species which does not form a fishery of any importance in any place except certain centres in the Gulf of Mannar and Palk Bay. Therefore, it was decided to take up the studies on Indian Decapods with special reference to the taxonomy of Penaeidae, Caridea and Paguridea and the biology of Penaeus semisulcatus at the instance of Dr.S. Jones, who was then Director of the Central Marine Fisheries Research Institute. The work was done during the period November, 1966 to November, 1969 and the results of the same are embodied in the present thesis. The complete analysis of the data and interpretation of the results have been done by me.

The descriptions of 31 species of penaeid prawns, 5 species of hippolytids, 9 species of palaemonids, 3 species of alpheids, 1 species of eusthenophyllid, 31 species of diogenid, 5 species of paguridand 4 species of coenobitid hermitcrabs totalling 92 species belonging to 31 genera are given in the first part of the thesis dealing with the taxonomy.

The second part consists of a section on the biology of P.semisulcatus with detailed studied on the food and feeding habits, length/weight relationship, relative condition factor, gonado-somatic index, age and growth, sex ratio, maturity and spawning, etc., and the other sections dealing with the important features of the fishery of the species in the Palk Bay and Gulf of Mannar. Since there are no published accounts of these aspects of the biology and fishery of Penaeus semisulcatus except the remarks on the food item and feeding habits by Hall (1962) this part forms an original contribution to the knowledge of the biology and fishery of this species in particular and penaeid prawns in general. The importance of this species to the prawn fishery and thus to the economy of this region makes the present study more valuable, especially when so much work has ever been done in this part of the country.

I wish to express my indebtedness to Dr.S. Jones, former Director, Central Marine Fisheries Research Institute, Mandapam Camp, at whose instance, supervision and guidance these investigations have been carried out. I am grateful to Dr. S.Z. Qasim, Director, Central Marine Fisheries Research Institute, Cochin, for his advice, help and encouragement. I am specially thankful to Dr.R. Velappan Nair, Deputy Director of this Institute for his help and valuable suggestions. My thanks are due to Mr.S.K. Banerji, Senior Fishery Scientist of this Institute for his advice in the statistical analysis of the data and for going through the type-script and to Dr.M.J. George, Scientist, National Institute of Oceanography for critically going through the thesis. I extend my thanks to Mr. Satyaprakash Chanchani, Artist-Photographer and Mr. P. Raghavan, Draughtsman-cum-Photographer of this Institute who have taken photographs of many specimens. I wish to thank Messrs. K. Ranga Rajan, N. Kumaran, P. Parameswaran Pillai, M. Ali Manikfan and Dr.C.S. Gopinatha Pillai for the collections from Andaman and Minicoy

Islands and the Laccadive Archipelago. I am thankful to Dr. P.A. Thomas, Messers. G.P. Kumaraswamy Achari, K.S. Sundaram and K.M.S. Ameer Hamza for identifying certain sponges, polychaetes, gastropod shells and foraminiferans respectively. To my several other colleagues in this Institute I am grateful for their help in many ways during the present investigations.

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M . M . Thomas

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1. Thomas, M.M. 1969 On a new distributional record of Parapenaeopsis hungelia (Muto) from the south-eastern coast of India. J.mar.biol.Ass.India, 10(1):166-167(1968).

2. _____ 1971 Notes on some interesting penaeid prawns (Crustacea,Decapoda) from the southeast coast of India. J.mar.biol.Ass.India, 11(1 & 2):191-197 (1969).

3. _____ 1971 Metapenaeopsis hornelli (de Man) a penaeid prawn (Decapoda, Penaeidae) new to the Indian Ocean. J.mar.biol.Ass.India, 12(1 & 2): 213-216 (1970).

# INTRODUCTION

The present knowledge of the taxonomy of Indian decapods is mainly due to the pioneering work started during the last decade of the nineteenth century by veteran carcinologists like Wood-Mason (1891, 1892), Henderson (1888, 1893, 1896, 1915), Anderson (1894, 1899), and Alcock (1894, 1899). They described the decapods collected from greater depths during the cruises of H.M.Indian Marine Survey Steamer "Investigator". Henderson has described the hermitcrabs collected by "Challenger" (1888) and from Chilka Lake (1915). Henderson and Matthai were the first to give an account of South Indian palaemonids. Alcock (1905, 1906) has given the descriptive catalogues of hermit crabs and prawns in addition to the deep sea decapods (1901). Kemp (1914, 1916, 1917a & b, 1925) has described decapods in the Indian Museum as also the decapod crustaceans of Chilka Lake (1915) and Hatlah River in the Gangetic Delta (1917). Gravely (1927) gave an account of the decapods collected from Krusadai Island in the Gulf of Mannar as well as the shells of these animals washed ashore on the Madras coast (1941). Sundara Raj (1927) has dealt with the paguride of the Krusadai Island. Chopra (1939, 1943) has elaborated on the food prawns and crabs of India and there fisheries. Chopra and Tiwari (1949) have given an account of the decapods of Patna State. Tiwari has contributed much to our knowledge of the fresh-water prawns and fossil penaeids from Rajpurdi (1947, 1955, 1963). Menon (1933, 1937, 1938, 1940) was the first to study the larval stages of the decapods from Madras. His subsequent works deal with the bionomics of the most important species of penaeid prawns on the southwest coast of India viz. Metapenaeus dobsoni Miers and Parapenaeopsis stylifera (Milne-Edwards) (1951, 1953, 1955, 1957). His work on the paddy field prawn fishery of Travancore-Cochin, prawn fishery of the Cochin backwaters, with special

reference to stake nets are other important contributions in the field. By far the most important contribution is that of George (1963, 1964, 1966a, 1966b, 1967, 1970a & b) who has considerably increased our knowledge of the taxonomy of Indian decapods by describing some new species of penaeid prawns and reporting new records in distribution of this group. His studies on the bionomics of Metapenaeus monoceros Fabricius (George,1959) including location of its possible spawning area off Cochin (George, 1964) and other aspects in relation to the fishery of the penaeid prawns of southwest coast of India such as breeding and recruitment (George, 1962a) larval abundance as possible index of fishing success (George, 1963) assessment of marine prawn resources of Kanyakumari District, southwest coast of India (George, 1966), size distribution and movement of commercial prawns (George, 1968), etc.,have enriched our understanding of the various aspects of the biology and behaviour of commercially important penaeid prawns. Kunju (1956) studied the biology of the palaemonid prawn Leander styliferus Milne-Edwards from West Bengal in addition to the notes on the taxonomy, biology and fishery of other species from Bombay (Kunju, 1960a, 1960b, 1967, 1968). Rajyalakshmi has made observatio on the embryonic and larval development (Rajyalakshmi, 1960) and maturation and breeding (Rajyalakshmi, 1961a) of estuarine palaemonid prawns. Besides, her studies on the biology and fishery of Metapenaeus brevicornis (Milne-Edwards) in the Hooghly estuarine system (Rajyalkshmi, 1961b) as well as the age and growth of some of these estuarine forms (Rajyalkshmi, 1966) are important works on these prawns inhabiting the great estuarine systems. Ramamurthy (1963a, 1963b, 1964) and Muthu (1965, 1970, 1971) have studied the taxonomy and fishery of prawns from Kutch on the west coast and Andhra on the east coast of India respectively. Rao (1970) has described a new species of sergestid shrimp Acetes cochinensis from Cochin backwaters.

Besides, his studies on the maturation and spawning of penaeid prawns of the southwest coast of India (Rao, 1968) and the larval studies of these prawns are other contributions. The penaeid prawns in the commercial shrimp fisheries of Bombay and the fluctuationsof species and size and the studies on the size distribution of commercial prawns of southwest coast of India were studied by Mohamed (1967a, 1967b, 1968) in addition to observations on the paddy field prawns filtration of Kerala (Mohamed, 1968).

Others who have contributions to this field from the Indian region are Ahmed (1957) on prawns andprawn fisheries of East Pakistan; Tirmizi (1962, 1967, 1968a, 1968b) on prawns of West Pakistan; Gopinath (1953, 1956), Mateusi (1942, 1945, 1947, 1948), Kurian (1953, 1954, 1964, 1965) and John (1957, 1958) all on prawns from Kerala Coast; Raman (1964, 1967) on the giant freshwater prawns Macrobrachium rosenbergii de Man; Shaikmahmud and Tombe (1958, 1960, 1961) on reproductive system of Parapenaeopsis stylifera (Milne-Edwards) and maturation of the ovaries; Subramanyan (1963, 1965, 1967) on reproductive cycles of Penaeus indicus (Milne-Edwards), bionomics of Metapenaeus affinis from Malabar coast and Thomas (1969, 1971) on new records of some penaeid prawns from southeast coast of India.

Studies on the taxonomy and biology of the shrimps and hermit crabs of the Indo-Pacific have been done by Haswell (1884), Dall (1957,1967), Racek (1956, 1959) and Racek and Dall (1965) from Australia; Hall (1956, 1958, 1961, 1962) Nobili (1903a) and Johnson (1961, 1963, 1965, 1966) from Malay Peninsula; Stebbing (1905, 1910, 1914, 1915, 1917), Barnard (1936, 1947, 1950) and Joubert and Davies (1965, 1966); Borradaile (1898, 1899, 1901), Hilgendorf (1869, 1879) Miers (1878, 1880, 1884), Coutiere (1903, 1905,1908, 1909, 1921) and Pechanec (1964) from Indian Ocean; Nobili (1906a & b) from Red Sea; Pino

and Serene (1955) from Viet Nam; Yap-Chiongco (1938) and Estampador (1937) from Philippines; Lee (1969) from Taiwan, Tesso (1915), Yokoya (1933, 1939) and Kubo (1936, 1943, 1949, 1951, 1954, 1955, 1956) from Japan and others.

## MATERIAL AND METHOD

The material for the present study on the taxonomy of the decapod crustaceans from Indian waters has been collected from all along the Indian coastline between Bombay to Cape Comorin on the west coast and from Cape to Waltair on the east coast (Map-1). The centres of collection on the west coast are Bombay, Mangalore, Cannanore, Koshikode, Ponnani, Ashicode, Cochin, Neendakarai (Quilon), Colachel and Cape Comorin. Extensive collections were made from the Gulf of Mannar and Palk Bay. From the Gulf of Mannar specimens were examined from Tuticorin, Kilakkarai, Periapatnam, Pudumadam, Vedalai, Mandapam Camp, Mandapam, Tonithurai, Rundugal besides from the coral reefs and lagoons of the islands such as Vala tivu, Hare Island, Manauli Island, Pulli and Pullivasal Islands, Krusadai and Shingle Islands. Collections were also made from Rameswaram, Devil's Point, Thangachimadam, Mandapam, Thodai, Pullimadam, Irumeni, Athankarai, Pamikulam, Devipattinam, Thiruppalakudi, Tondi, Sethubavachathram, Adirampattinam and Muthupet in Palk Bay. The Coromandel Coast was represented by material from Point Calimere, Nagapattinam, Karaikal, Tranquebar, Cuddalore, Pondicherry, Madras and Pulicat Lake. Besides, specimens from Kakinada and Waltair were also examined. Shrimps and hermit crabs were obtained from Andaman and Nicobar Islands as well as from the islands of Laccadive Archipelago.

The specimens were collected either from the catches of the fishing units landed in these centres or from the shallow waters with scoop net or dip net. The material was preserved in Alco-glycero-formol (neutralised 5%

formaldehyde solution, glycerine and rectified spirit in the ratio 6:2:2) which was found to be much better than 5% formaldehyde solution. Most of the material was obtained from the depths upto 30 metres. Some deepsea forms were collected from 200 to 400 m by the deepsea fishing vessels of the Indo-Norwegian Project off the coasts of Kerala in the Arabian Sea and Mandapam in the Gulf of Mannar. Carapace length was taken linear measurement in all cases.

For the studies on the biology of the green prawn Penaeus semisulcatus de Haan regular samples were collected during the period April, 1967 to April, 1969 from the trawl catches landed at Mandapam on the Palk Bay and Gulf of Mannar side depending on the fishing seasons. In the year April 1967 to April 1967 the fishing in Palk Bay was restricted to the months of April, 1967 to October 1967 and March 1968, while during the period November, 1967 to February 1968 fishing was done in the Gulf of Mannar. In the succeeding year (1968-69) the fishing season in Gulf Mannar was from December, 1968 to March 1969. Depending on the availability of the prawns, weekly or fortnightly samples were taken at random from the catches of the mechanised boats so that about 100 specimens were examined for biology and about 500 for length frequency studies. The samples were sorted into males and females and the carapace and total lengths were measured to the nearest millimetre. Weights were taken correct to 0.1 gram separately for males and females. The males were examined to know whether they have attained maturity. The colour and size of the ovaries of female specimens were noted to determine the maturity stages. The sample of ovaries were preserved for ova diameter studies and full ovaries were carefully dissected for fecundity studies. The stomachs of specimens of both sexes representing all the size ranges, were also removed and preserved for analysis of the stomach contents. Further details of the procedure followed,

for the various aspects of the studies, are given in the appropriate places

The food items encountered in the stomach contents were identified upto the generic or specific levels as far as possible, although they are grouped under broad divisions. The quantitative analysis was carried out independently by the points (volumetric) method (Pillay 1952) while the occurrence also was taken into account. The "Index of Preponderence" method of Natarajan and Jhingran (1961) was followed.

After determining the length-weight relationship the relative condition factor was calculated. The ova diameter measurements were taken to study the development of ova to maturity. The relations between the weight of fish and the weight of the gonad and the relative ovary weight and maturity were also determinined. The fecundity of the species was calculated from the estimation of the number of ova contained in a known portion of the whole ovary of known weight. Monthly sex ratios were determined from the percentage frequency of males and females in the samples examined during the course of investigations. The length frequency data was pooled for every month and the age and growth were calculated by Peterson's method and the results were verified making use of Bertalanffy's equation.

The various aspects of the fishery of Penaeus semisulcatus in Palk Bay and Gulf of Mannar with special reference to the fishing seasons and fishing grounds are given in the last chapter. Details of the monthwise prawn landings at Mandapam from Palk Bay and Gulf of Mannar in relation to the other marine landings, their disposal and the impact of the prawn fishery on the economy of the area are also briefly discussed.

# PART I - TAXONOMY OF INDIAN DECAPODS

## ORDER DECAPODA

The suborders Natantia (sections Penaeidea and Caridea) and Reptantia (section Anomura) were covered during the present investigations on the Indian decapods.

### Suborder Natantia

#### Section 1. Penaeidea

Family Penaeidae alone is represented in the collections.

#### Family Penaeidae Rafinesque, 1815

#### Key to the subfamilies of the Penaeidae

1. Insertion of upper antennular flagellum near posterior border of 3rd antennular segment, lower antennular flagellum longer than upper. .. .. .. .. Aristaeinae
- Insertion of upper antennular flagellum at the apex of 3rd antennular segment, lower antennular flagellum equal or subequal to the upper. .. .. .. ..

2. Postorbital spine present, cervical sulcus reaching to or almost to midderal line. .. .. Solenocerinae
- Postorbital spine absent; cervical sulcus extending to 2/3 or less the distance between hepatic spine and dorsum. ..

3. Procarinae present; exopods usually present on 2nd and 3rd maxillipeds; pleopods with 2 rami. .. Penaeinae
- Procarinae absent; no exopods on 2nd and 3rd maxillipeds; pleopods with 1 ramus only. .. Sicyoninae.

The subfamilies Solenocerinae and Penaeinae are represented in the collections.

## Subfamily Solenocerinae Wood-Mason & Alcock 1891

### Key to the Indian genera of Solenocerinae

1. Antennular flagella cylindrical or subcylindrical; posterbital spine absent; an arthrobranchia supported on 7th body segment.
- Antennular flagella foliaceous, posterbital spine present; suprahepatic spine absent; peteasma furnished with numerous setae along distal margins; pterocardiac ossicle bifurcate at outer end; two arthrobranchia lie on 7th body somite .. Solenocera Lucas
2. A rudimentary podobranchia absent on 3rd and 4th thoracic somites. 3
- A rudimentary podobranchia present on 3rd and 4th thoracic somites. .. .. .. Hymenopenaeus Smith
3. Suprahepatic spines present; peteasma without numerous setae along distal margins; pterocardiac ossicle simply bar-shaped. Parahaliporus Kubo
- Suprahepatic spines absent; peteasma with numerous setae along distal margins; pterocardiac ossicle bifurcate at outer end. Haliporus Bate

### Genus Solenocera Lucas 1850

### Key to the Indian species of Solenocera

1. Telson trifurcate .. .. ..
- Telson simple and devoid of any spine on lateral margin .. .. .. .. S. crassicornis H. Milne Edwards
2. Interno-distal margin of exopod of uropod with spine .. ..
- Interno-distal margin of exopod of uropod without spine ..

3. Postrostral carina present in posterior half of carapace; cervical groove indents the carapace middorsally. S. waltairensis George & Muthu

- Postrostral carina absent in posterior half of carapace; cervical groove does not indent carapace middorsally. S. pectinata (Bate)

4. Spine on cervical groove ventral to posteriormost spine of rostral series present; 'L' shaped groove on either side of branchiostegal region present .. .. .. .. S. hextii Wood-Mason

- Spine on cervical groove ventral to the posteriormost spine of rostral series absent; no 'L' shaped groove on either side of branchiostegal region. .. .. .. 5

5. Postrostral carina markedly elevated, laminose.. S. alticarinata Kubo

- Postrostral carina not markedly elevated, not laminose. .. .. 6

6. Cervical groove indents the postrostral carina deeply. .. .. 7

- Cervical groove does not indent the postrostral carina. S. melantho de Man

7. Antennular flagellum longer than carapace including rostrum, gradually tapering to a point ... ... S. koolbali de Man

- Antennal flagellum as long as carapace including rostrum and tapers abruptly towards broadly rounded apex. .. S. shoyoni Natarajan

Solenocera crassicornis and S. hextii were collected during the present investigations.

Solenocera crassicornis H. Milne Edwards, 1837

(Pl.VIII, 1)

Penaeus crassicornis H. Milne Edwards, 1837:412.

Solenocera crassicornis Bate, 1881:185; Wood-Mason and Alcock, 1891: 275-276; Henderson, 1893:452; Bouvier, 1908; de Man 1911:7; Burkenroad, 1934a:71; Menon, 1940:3-6.

Philonicus grassicornis Bate, 1888:278.

Solenocera indicus Natarajan, 1945:94; Ahmed, 1957.

Solenocera indica Kunju, 1968:1-12 (Part Synonymy); 1969:159-163; George, 1969:17; Jones, 1969:743.

Material: 37 specimens. Kakinada (5-12-1968) 1 female, carapace length 20 mm; Nagore (12-11-1968) 1 female, 17.4 mm; 2 males, 10.2, 10.3 mm; Kacha Tivu, Palk Bay (12-4-1969) 1 male, 30 mm; Off Mandapam, Gulf of Mannar (25-3-1969) 2 males, 11, 19.5 mm; Nagapattinam (20-3-1969) 1 female 15 mm; 4 males, 12.75 to 15 mm; (2-3-1967) 12 females, 11.3 - 23.6 mm; 3 males, 14.5 - 19.8 mm; Cuddalore (27-2-1967) 3 females, 13.2 - 14.3 mm; Bombay (18-11-1967) 5 females, 16.1 - 26 mm. Collected from shore seine and trawl net catches. Depth of occurrence: 2 - 25 m.

Discussion: The species has been confused by many workers, probably due to the very brief description given by Milne Edwards. It was not clear which were the four spines on the carapace mentioned by him, although he had clearly given the other important taxonomic character viz., the absence of the lateral spines of telson which is shared only by S. subnuda Kubo among the other species of the genus. Bate (1891) in his definition of the genus Solenocera states "..... Four teeth on each side of the carapace one at the outer orbital angle, one supraorbital, one hepatic and one near the antero-inferior angle of carapace" and assigns S. membranacea (Fabr.), S. grassicornis (M.Edwards) and S. longani Bate to the genus. Besides, Wood-Mason and Alcock (1891) have clearly mentioned the absence of both the pterygostomian and branchiostegal spines in S. grassicornis described by them. Therefore, it is quite probable that the four spines mentioned in the original description are supraorbital, posterolateral, antennal and hepatic spines only. These spines are present in S. indicus Natarajan also. Thus it is clear that S. indicus is only a synonym of S. grassicornis.

The four spines on the carapace are well defined in the present material from Kakinada, Coromandel Coast as well as Bombay. The specimens agree well with the earlier descriptions.

Distribution: Indo-Pacific from west coast of India (H.Milne Edwards, 1837; Bate, 1881; Nataraj, 1945; Kunju, 1966); east coast of India (Bate, 1818; Henderson, 1893; Nataraj, 1945; Ahmed, 1957; George, 1969); Gulf of Martaban (Henderson 1893) and East Indies (Bate, 1881).

*Solenocera hextii* Wood-Mason 1891

(Pl.VIII, 2)

*Solenocera hextii* Wood-Mason, 1891:275; Alcock, 1901:20-21; de Man, 1911:7; Ramadan, 1938:56; Anderson and Lindner, 1943:286 (in Key); George, 1966:338; 1969:18.

Material: Several specimens. Off Mandapam, Gulf of Mannar (26-8-1969) several males, carapace length 16 - 23.5 mm; several females, 19 - 44 mm. Collected from trawl catches. Depth of occurrence:250 - 300 m.

Diagnosis: Postrostral carina is sharp; but not laminose. Antennular flagella with red and white bands. The spine on the cervical groove situated ventral to the posteriormost postrostral tooth is well developed. The characteristic 'L' shaped groove on either side of the branchiostegal region are also clearly defined. There is a well developed stout and blunt spine on the outer distal end of the exopods of uropod. The structure of the thelycum and petasma conforms with the earlier descriptions.

The species which is much larger than *S. crassicornis* is fished in lesser quantities from the offshore grounds off Quilon, on the southwest coast of India along with other deep sea prawns. Recently good quantities of this species were caught from Gulf of Mannar, off Mandapam. Due to the larger size they are

more economical for the fishermen and canners. The virgin grounds in the Gulf of Mannar is yet to be exploited by the fishing industry.

Distribution: Gulf of Aden (Ramadan, 1938); Arabian Sea (Ramadan, 1938); west coast of India (George, 1966; 1969); Bay of Bengal (Wood-Mason and Alcock, 1891; Alcock, 1901).

This is the first report of the species from the Gulf of Mannar.

## Subfamily Penaeinae Rafinesque 1815

Six genera viz., Penaeus, Metapenaeopsis, Trachypenaeopsis, Metapenaeus, Trachypenaeus and Parapenaeopsis which are found to occur on east and west coasts of India are studied.

### Key to Indian genera of Penaeinae

| | |
|---|---|
| Rostrum with ventral teeth . .. .. | Penaeus |
| Rostrum without ventral teeth .. .. .. | 2 |
| Petasma symmetrical; 3rd maxilliped usually without basial spine | 3 |
| Petasma asymmetrical; 3rd maxilliped with basial spine .. .. .. .. | Metapenaeopsis |
| Telson with a large pair of subapical fixed spines; a spine which may be minute, on the ventral distomedian border of 1st segment of antennular peduncle .. .. .. | 4 |
| Telson without a pair of large subapical fixed spines but often with lateral movable spines; no spine on the ventral distomedian border of 1st segment of antennular peduncle .. .. | 6 |
| Carapace with longitudinal sutures .. .. | Parapenaeopsis |
| Carapace without longitudinal sutures .. .. .. | 5 |

5. Branchiostegal spine present; petasma with a pair of large spiniforms distolateral projections. .. Penaeopsis

- Branchiostegal spine absent; petasma with a pair of tubular distolateral projections. .. Trachypenaeopsis

6. A pleurobranch on 7th thoracic somite; no exopod on 5th pereiopod. .. .. Metapenaeus

- No pleurobranch on 7th thoracic somite; an exopod on 5th pereiopod. .. .. 7

7. Mastigobranchiae on 3rd pereiopods. .. Trachypenaeus (Alcock)

- Mastigobranchiae absent on 3rd pereiopods .. Parapenaeopsis

Genus Penaeus Fabricius 1798

Key to Indian species of Penaeus

1. Adrostral carina reaching almost to posterior border of carapace; gastrofrontal carina present. .. .. 2

- Adrostral carina not reaching behind middle of carapace; gastrofrontal carina absent. .. .. .. 4

2. Telson armed, usually with 3 pairs of spinules. .. 3

- Telson unarmed rostrum with 1 ventral tooth .. P. canaliculatus

3. Thelycum with apex of anterior plate rounded; seminal receptacle cylindrical, not closed by 2 flaps; adrostral sulcus narrower than postrostral carina. .. .. .. P. japonicus

- Thelycum with apex of anterior plate bifid, seminal receptacle flat, closed by 2 flaps; adrostral sulcus as wide as postrostral carina. .. .. .. P. latisulcatus

4. Hepatic carina present .. .. .. .. 5

\- Hepatic carina absent .. .. .. 6

5. Fifth pereopods without exopods; hepatic carina straight, horizontal. .. .. .. .. P. monodon

\- Fifth pereopods with small exopods; hepatic carina inclined towards branchiostegal angle .. .. .. P. semisulcatus

6. Gastro-orbital carina occupying the posterior 2/3 distance between hepatic spine and orbital angle. .. P. indicus

\- Gastro-orbital carina absent or not reaching hepatic spine and occupying the middle 1/3 distance between hepatic spine and orbital angle. .. .. .. 7

7. Dactyl of 3rd maxilliped adult ½ propodus; adrostral carina reaching as far as epigastric tooth. .. .. P. merguiensis

\- Dactyl of 3rd maxilliped adult much longer than propodus; adrostral carina reaching just beyond epigastric tooth. P. penicillatus

The present collection contains seven species of the genus Penaeus viz. P. japonicus, P. latisulcatus, P. canaliculatus, P. monodon, P. semisulcatus, P. indicus and P. merguiensis.

Penaeus japonicus Bate 1888

Penaeus canaliculatus var. japonicus Bate, 1888:245-248.

Penaeus canaliculatus Ortmann, 1890:488; Kishinouye, 1900:11-12; Rathbun, 1902:37; Yatsui, 1942:468; Menon, 1956: 345 (Key).

Penaeus semisulcatus Alcock, 1906:14-16 (Part synonymy).

Penaeus japonicus Nobili, 1906:10; de Man, 1911:107; Stebbing, 1914a; Balss, 1914:13; Tattersal, 1921:367; Kubo, 1949: 273-278; Barnard, 1950:590-592; Hall, 1956:71; 1962:14; 1966:98; Dall, 1957:142(Key); Rnock and Dall, 1965:12; Cheng-Ming, 1965:2; Joubert, 1965:15-16; Joubert and Davies 1966, 10-15; Ganapathi and Subramanyam, 1966:12; Tirmizi, 1969:753, fig.2, A-D.

Material: 2 specimens. Pulicat Lake (7-11-68) 1 male, carapace length, 28.1 mm; Pamban, Palk Bay (7-7-70) 1 female, 28 mm. Collected from stake net and trawl catches. Depth of occurrence:2 - 12 m.

Discussion: This widely distributed species occurs in small numbers in Bombay Coast as well as coasts of West Pakistan. It forms a minor fishery in Pulicat Lake and along the Madras Coast. This is the first record of the species from the Palk Bay. The specimens in the present collection agree with the description given by Alcock (1906) and Kubo (1949) in all details. The first, fourth and fifth legs reach the same point anteriorly, when fully extended as in the case of the specimens of Kubo although Hall (1962) has stated that in the specimens collected by him from Singapore the second, fourth and fifth legs attain same point anteriorly.

Distribution: Red Sea (Tattersal, 1921; Nobili, 1906a); west coast of India (Natarej, 1942; Tirmizi, 1967; George, 1969); South Africa (Barnard, 1950; Joubert, 1965; Joubert and Davies 1966); East Africa (Ortmann, 1890); east coast of India (Alcock, 1906; Ahmed, 1957; Ganapathi and Subramanyam, 1966; George, 1969); Andamans (Alcock, 1906); Singapore (Hall, 1956; 1962; 1966); Japan (Bate, 1888; Ortmann, 1890, Kishinouye, 1900; Rathbun, 1902; Alcock, 1906; Kubo, 1949); Taiwan (Cheng-Ming, 1965); East Indies (Ortmann 1890); Australia (Rnock and Dall, 1965).

**Penaeus latisulcatus** Kishinouye, 1900

**Penaeus latisulcatus** Kishinouye, 1900:12; de Man, 1911: 108-11; Kubo, 1949:278-282; Knock, 1955:222-225; Hall, 1955:72; 1962:14-15; 1966-98; Dall, 1957:149-151; Knock and Dall, 1965:12-13; de Bruin, 1965:74-75; Joubert, 1965:17-18; Cheng-Ming, 1965:3; Mohamed, 1969:29; George, 1969:22; Thomas, 1971:191-192.

**Penaeus latisulcatus** Schmitt, 1926:365-367.

**Penaeus canaliculatus** Oliv, var? Lanchester, 1901:571.

**Penaeus canaliculatus** var. **australiensis** de Man, 1902:905.

Material: 17 specimens. Rameswaram, Palk Bay (14-2-68) 1 male, carapace length, 29mm and 2 females, 27, 30 mm; Vedalai, Gulf of Mannar (18-11-66) 4 males, 14 - 18.5 mm; 1 female, 17 mm; (5-12-66) 9 males, 17 - 26 mm and 1 female, 15 mm; Pudumadam, Gulf of Mannar (20-12-68) 1 male, 33 mm and 3 females, 38 - 45 mm. Mandapam, Gulf of Mannar (8-11-69) 1 female 32.1 mm. Collected from the night catches of trawl nets. Depth of occurrence 1 - 12 m.

Discussion: The specimens agree with the description given by Dall and others. The bifid processes of the anterior plate of the thelycum are stumpy in young ones, while long and slender, their tips turning inwards in the adults as described by Thomas (1971). This is contrary to the finding of de Man (1888). The young specimens from the Gulf of Mannar and Palk Bay were compared with specimens of the same size collected from the Islands of Laccadive Archipelago and they were found to be in close agreement.

Distribution: Red Sea (Nobili, 1906); South Africa (Joubert, 1965); west coast of India (Mohamed, 1969; George, 1969); Ceylon (de Bruin, 1965); Singapore

(Hall, 1956; 1962; 1966); Japan (Kishinouye, 1900; Kubo, 1949); Taiwan (Ching-Ming, 1965); East Indies (de Man, 1907); Australia (Racek, 1955; Dall, 1957; Racek and Dall, 1965).

## Penaeus canaliculatus Olivier 1811

Penaeus canaliculatus Olivier, 1811:660; H.Milne Edwards, 1837:414; Bate, 1881:174; 1888:243; Nobili, 1906:9; de Man, 1911:106-107; Barnard, 1950:590; de Bruin, 1965: 73; Joubert, 1965:18-20; Hall, 1966-96; George, 1969:21; Jones, 1969:741.

Material: 6 specimens: Miniocy Island (18-6-67) 1 male, carapace length, 16.5 mm; (14-1-67) 1 female, 18.4 mm; Addaanna (2-8-67) 1 male, 10.5 mm; 3 females, 19 - 19.5 mm. Collected from shore seine and trawl net catches. Depth of occurrence: 2 - 20 m.

Discussion: The golden branchiostegal spinules which are the distinguishing characters by which this species can be separated from P. japonicus which also has more or less similar colouration in life. The rostrum is with only one lower tooth as in P. japonicus. The thelycum also is characteristic in the shape and structure of the anterior plate.

The species has been noticed in small numbers in the stake net catches of the Korapuzha Estuary, though not forming a fishery. They remain alive for longer periods out of water than the other penaeid prawns and could be kept alive in sea water for several days in the laboratory.

Distribution: Red Sea (Nobili, 1906); South Africa (Barnard, 1950; Joubert, 1965; Hall, 1966); Mauritius (H.Milne-Edwards, 1837); Ceylon (de Bruin, 1965); East Indies (H.Milne-Edwards, 1837; de Man, 1911); Pacific Ocean (Bate, 1888).

## Penaeus monodon Fabricius 1798

Penaeus monodon Fabricius 1798:408; Haswell, 1881:199; Kishinouye, 1900:7,15; Pearson, 1905:69; Stebbing, 1910:380; Holthuis, 1949:105-107; Kubo, 1949:291; Barnard, 1950:584; Dall, 1957:152-154; de Bruin, 1965:76; Cheng-Ming, 1965:1; Joubert, 1965:22-24; Joubert and Davies 1966:10-31; Johnson, 1965:7; Racek and Dall, 1965:10-11; Hall, 1966:98; Tirmizi, 1969:755; George 1969:22-23; Mohamed, 1969:68-75; Jones, 1969:341.

Penaeus carinatus Dana, 1852:602; de Man, 1911:101; Kemp, 1915:317-319; 1918:294; Burkenroad, 1934a:74; Nataraj, 1942:468; Andersen and Lindner, 1943:305; Racek, 1955:215-17; Menon, 1956:345(Key).

Penaeus canaliculus Stebbing, 1905:77; Burkenroad, 1934a:74; Racek, 1955:217-218.

Penaeus kubuliu Kubo, 1949:296-301.

Penaeus semisulcatus Alcock, 1906:10-11.

Penaeus carinatus Schmitt, 1926:359-363.

Material: 12 specimens. Bombay (12-11-69) 1 male 27.6 mm; 1 female, 22.7 mm; Vembanad Lake, Kerala (10-6-67) 4 males, 12 - 12.75 mm; 2 female, 12.5 mm; Tuticorin (31-1-67) 4 males, 46 - 54 mm; Off Pudumadam, Gulf of Mannar (10-11-69) 1 male, 61 mm; 1 female 83 mm; Mandapam, Gulf of Mannar (13-2-71) 1 male, 48.9 mm. Collected from trawl catches. Depth of occurrence:12 - 30

Discussion: The present material agrees well with the earlier description in all details. The colouration difference noticed by Racek and Dall (1965) is seen in the young specimens from the Athankarai Estuary and Pullamadam Creek.

The dorsal bands of these specimens were greyish or even brownish. Very small specimens (6 mm carapace length) collected from the plankton also showed the dorsal colour band extending from the base of the rostrum to the sixth abdominal segment. These smaller specimens conform well to the characters of the species. The smaller ones have been often observed to cling to submerged vegetation in a vertical position.

Although the largest specimen recorded was 337 mm long (Racek and Ali, 1965) the largest specimen of this species collected from the trawl catches from the Gulf of Mannar during the present studies measured 300 mm (83 mm carapace length).

Distribution: Red Sea (de Man, 1880); W.Pakistan (Tirmizi, 1969); South Africa (Stebbing, 1910; Barnard 1950; Joubert 1965; Joubert and Davies 1966); West Coast of India (Alcock, 1906; George, 1969; Mohamed, 1969); Ceylon (Pearson,1905; Alcock, 1906); Chilka Lake (Kemp, 1915); East coast of India (Nobili, 1903 bis) Alcock, 1906); Mergui (Alcock, 1906); Andamans (Alcock, 1906); Singapore (Dana 1852; Johnson 1965); Siam (Kemp, 1918); East Indies (de Man, 1888); Japan (Kishinouye, 1900).

Penaeus semisulcatus de Haan 1850 (Pl.III, 1-3)

Penaeus semisulcatus de Haan 1850:191; de Man, 1888:284-286; 1911:97-100; Miers, 1878:299-300; Lanchester, 1901:570; Rathbun, 1908:315; Stebbing, 1914; Tattersal, 1921:367; Barnard, 1950:588; Racek, 1955:218-219; Ahmad, 1957; Dall, 1957:154-157; Racek and Dall, 1965:11; Joubert, 1965:20-22; Joubert and Davies 1966:10-16; de Bruin, 1965:76; Hall, 1966:98; Tirmizi, 1969:755; George, 1969:23; Mohamed, 1969:64-67; Jones, 1969:741.

Penaeus semisulcatus Schmidt, 1926:360-364.

Penaeus ashiaka Kishinouye, 1900:7-14; Ruthven, 1902:38; Nobili, 1903a:2; 1906:16.

Penaeus monodon Alcock, 1906:8; Bate, 1888:250; Rabe, 1949:291-296; Menon, 1956:345(Key).

Materials: Several specimens. Vedalai (26-4-67) 1 male, carapace length 20 mm; 4 females, 13.4-33 mm; Mandapam, Gulf of Mannar (17-12-67) 1 female, 41.5 mm; (13-9-68) 1 female, 50 mm; (18-2-69) 1 female, 48 mm; Mandapam (Palk Bay) (31-10-68) 1 female, 48.5 mm; (19-8-69) 1 female, 32.4 mm; Kovalam (21-3-67) 1 male, 27.2 mm; 1 female, 29.5 mm; Vedalai (6-10-67) 6 males, 15.1 - 24 mm; 7 females, 16.6 - 24.3 mm; (17-4-67) 8 males, 14 - 17 mm; 4 females, 14 - 18.5 mm; Marakayarpattinam (20-2-68) Several Specimens, 6 - 17 mm. Depth of occurrence 2 - 15 m.

Discussion: This extensively described species having wide distribution in the Indo-Pacific is the most common species of Penaeid prawn in the Gulf of Mannar and Palk Bay, forming almost 99% of the commercial catches of prawns by trawlers. This tropical species seems to prefer areas with rocks and corals with the accompanying vegetation. The young ones usually seen among the sea weeds and turtle grass in the near shore areas and generally acquire light to live green colour of the surroundings. The colour of older ones is generally ash grey to reddish brown, depending on the environment. Specimens from muddy bottom are ash while those from sandy or rocky areas are reddish brown with bright red legs and their setae.

The present material does not offer any additional criteria for further description.

Distribution: Red Sea (Nobili, 1906; Tattersall, 1921); W.Pakistan (Tirimini, 1969); S.Africa (Stebbing 1914b; Barnard, 1950; Joubert 1965, 1966); East Coast of India (Alcock, 1906); Singapore (Ortmann, 1890; Nobili, 1905a; Ahmad 1957); Mergui Archipelago (de Man 1888); Malaya, Peninsula (Lanchester 1901); Philippines (Bate, 1888; Miers, 1878); Formosa (Miers, 1878); East Indies (de Man 1888; Rathbun, 1908); Japan (de Haan 1850; Ortmann, 1890; Kishinouye, 1900 and Rathbun 1902); Australia (Miers 1878); Pacific Ocean (Miers 1878).

Penaeus indicus H. Milne Edwards 1837

Penaeus indicus H. Milne Edwards 1837:350; Dana, 1852:604; Heller, 1865:122; Miers, 1878:301; Bate, 1888:248; Lanchester, 1900:471; Pearson, 1905:69; Ramadan, 1938:62; Nataraj, 1942:468; Kubo, 1949:311-315; Barnard, 1950:588-590; Racek, 1955:220-221; Menon, 1956:346(Key); Hall, 1956: 75; 1962:16; 1966:98; Ahmad, 1957; Dall, 1957:169; Cheung, 1960:67-68; Racek and Dall, 1965:15-16; Crosnier, 1965:29; de Bruin, 1965:76; Joubert, 1965: 24-26; Joubert and Davies, 1966:10-31; Cheng-Ming, 1965:4; Tirimini, 1969:749-764; Rao, 1969:26; George, 1969:23-24; Mohamed, 1969:49-64; Jones, 1969:739-741.

Penaeus indicus var. longirostris de Man, 1892:511.

Penaeus semisulcatus Stebbing, 1915:69.

Penaeus indicus Alcock, 1906:12; Schmitt, 1926:361.

Material: 25 specimens. Kovalam (21-3-69) 1 male, carapace length 32.1 mm; Mandapam Camp, Palk Bay (18-10-67) 11 males, 19 - 27 mm; 2 females, 18.5, 20 mm; (8-11-66) 1 male, 14.5 mm; 10 females, 6 - 19 mm. Collected from boat seine at Kovalam and from the lagoon at Mandapam Camp. Depth of occurrence 1 - 20 m.

Discussion: This species, although closely related to P. penicillatus and P. monoceros can be easily distinguished in the adult stage, by the backward extension of the adrostral sulci to the epigastric tooth and the proportion between the dactylus and propodus of the third maxilliped. Mature specimens as well as juveniles collected during the present investigations agree well with the description of earlier workers. This species forms a negligible portion of the catches landed from the Gulf of Mannar and Palk Bay and they are caught mostly from the off shore fishing grounds. Juveniles are often collected in large numbers from the Athankarai Estuary and Pullamadam Creek and lagoon on the Palk Bay side. In Gulf of Mannar catches from 'off shore waters' contained larger specimen with ovary in advance stages of maturity, indicating that this species is likely to spawn in deeper waters of the gulf as in other part of the Indian coast.

This is one of the most important species of Penaeid prawns which is found to inhabit most of the estuaries and creeks along the Indian coast. In Kerala this forms the major constituent of the catches from sea as well as estuaries, P. indicus is highly Sought after by the freezers and canners due to the better quality and appearance of the meat.

Distribution: West Pakistan (Tirmizi, 1969); West Coast of India (Mohamed, 1969; George, 1969); South African (Barnard, 1950; Joubert, 1965); Madagascar (Crosnier, 1965); Madras (Panikkar & Aiyer, 1937, 1939); Chilka Lake (Kemp, 1915); Hoogly Estuary (Rao, 1969); Pakistan (Ahmad, 1957); Ceylon (Pearson, 1905; de Bruin, 1965); Singapore (Dana 1852; Hall, 1956; 1962; 1966); Malaya (Kemp, 1918); Hong Kong (Cheung, 1960); Taiwan (Cheng-Ming, 1965); Australia (Racek, 1955; Dall, 1957; Racek and Dall, 1965).

## *Penaeus merguiensis* de Man 1888

*Penaeus merguiensis* de Man 1888:287-290, pl.18, fig.3 and pl.19, fig.1; 1911:104-105; Kubo, 1949:308-311; Racek, 1955:221-222; Hall, 1956:74-75; 1962:15; Dall, 1957:160-162; Cheung, 1960:67; Joubert, 1965:14(Key); de Bruin, 1965:76; Johnson, 1965:7; Racek and Dall, 1965: 16-17; Tirmizi, 1969:757; Tuma, 1966:73-88; Kirkegaard, Tuma and Walker, 1967; Jones, 1969:741.

*Penaeus indicus* Bate, 1888:248.

*Penaeus indicus* var. *merguiensis* de Man, 1892:511; Menon, 1956:346(Key)

*Penaeus indicus* var. *merguiensis* Alcock, 1906:13.

*Penaeus merguiensis* Schmitt, 1926:360-361; Boone, 1935:96-101.

Material: 7 specimens. Tuticorin (31-1-67) 1 male, carapace length, 37 mm; Mandapam, Gulf of Mannar (18-11-66) 3 males, 30 - 32 mm; 1 female, 47 mm (8-1-69) 2 males 36, 35.6 mm; (27-11-70) 1 female 55 mm. Collected from trawl net catches. Depth of occurrence 10-20 m.

Discussion: *P. merguiensis* can be easily distinguished from the other two allied species viz. *P. indicus* and *P. penicillatus* by the deltoid crest of the rostrum which is usually reddish in colour with darker margins, in adult specimens. Dactyl of 3rd maxilliped in adult male is only $\frac{1}{3}$ propodus in *P. merguiensis* while in *P. penicillatus* it is longer than propodus. The gastro-orbital carina is clearly defined in adults as Dall (1957) has pointed out in the case of his material from Karachi; although this is not a case in his specimens from Australia. Large adults are caught from the offshore areas in the Gulf of Mannar and Palk Bay. Mature females have been collected from deeper waters only.

P. mennonensis is rarely caught in the inshore areas while very small numbers are encountered in the offshore catches, especially from the Gulf of Mannar. They are common in the Athankarai Estuary and Pullamadam Creek.

Distribution: West Pakistan (Alcock, 1906; Tirmizi, 1969); south west coast of India (George, 1969; Mohamed, 1969); Ceylon (de Bruin, 1965); east coast of India (Alcock, 1906); Mergui Archipelago (de Man, 1888); Singapore (Johnson, 1965); Hong Kong (Chuang, 1960); Philippines (Bate, 1888); East Indies (de Man 1898) 1911); Japan (Kubo, 1949); Australia (Racek, 1955; Dall, 1957; Racek and Dall, 1965; Kirkegaard, Tuna and Walker, 1967).

Genus Trachypenaeopsis Burkenroad 1934

There are only two species known at present, one from western Indian Ocean and the other from the Atlantic. The present species collected from Minicoy Island, Laccadive Archipelago is new to science and the genus is reported for the first time from the Indian Region.

Key to the species of Trachypenaeopsis

1. Two pairs of distal projections visible in dorsal view of petasma; distolateral projections longer than distomedian; anterior plate of thelycum 5 times as long as wide .. T. richtersii (Miers)
- Three pairs of distolateral projections in dorsal view of petasma .. .. .. .. 2
2. Distolateral projections of petasma shortest; anterior plate of thelycum as long as wide. .. .. T. minicoyensis sp.nov.
- Proximolateral projections of petasma shortest. .. T. nobiliensis (Rathbun)

*Trachypenaeopsis miniceyensis* sp.nov.

(Pl.I, 1-13)

Material: 3 specimens. [illegible]n lagoon of Minicoy Island, Laccadive Archipelago. Holotype female, carapace length 8.1 mm (total length 31.5 mm); alletype male, 7.5 mm (29.5 mm) and paratype female, 8.5 mm (30mm). Collected by Mr. Ali Manikfan on 7-1-1967. Depth of occurrence: 3 m.

Description: Body glabrous except the tomentose area restricted to anterior and posterior portions of the cervical groove. Rostrum straight, pointed and laterally compressed, about one-fourth length of carapace, tip being slightly raised above dorsal profile and reaching nearly middle of first joint of antennular peduncle. The adrostral carina starts from the base of the terminal tooth, curves down to reach the level of epigastric tooth. Upper border with five to six teeth (two females have five and male has six) excluding epigastric which is situated well behind the rest of the series. Last two rostral teeth are borne on carapace. Rostral teeth are progressively longer backwards, anteriormost one being close to the distal end. Cervical groove is well defined, extending more than half way to middorsal line. Hepatic groove is sigmoidal, commencing a little behind hepatic spine. Antennal spine is stout while supraorbital and hepatic spines are smaller. Hepatic spine is placed posterior to plane of epigastric tooth. Pterygostomian angle is rounded.

Eye 3.8 in length of carapace, in longer diameter of cornea. Cornea 1.5 as long as broad. Pracartema falls short of dorsal margin of eye, being only half length of cornea. Stylocerite reaches middle of first antennular segment. Upper flagellum a trifle shorter than lower, and half the length of carapace. Length of third segment of antennular peduncle about 1/3 length of basal segment and 1/2 the second segment. Basicerite with sharp, pointed spine at the lower end, distolaterally. Scaphocerite bears an anterolateral

spine and extends beyond the tip of antennular pedunele.

Mandible with molar process having concave masticatory surface and a pointed projection at posteromedian angle. Anterior end of cutting edge of incisor process with a notch. Palps reach the base of carpocerite with subtriangular basal segment and anterior one broad and abruptly pointed at the distal end. It is about 1.4 times as long as wide and 1.8 the length of the basal segment. Maxillulary palp two segmented. Basal segment has a deep constriction at about middle and is ten times the length of the distal segment. There are four spinules on inner side of basal segment, increasing in size from proximal end. Maxilla typical, with short endoped bearing a few stiff spinules on the inner side. First maxilliped well developed, endoped five-jointed. Epipod also elongated, not bifid, broader than endoped and 2.2 times as long as broad. Second maxilliped has typical shape of an interrogation mark. In the third maxilliped the length of the dactylus bears the following proportions with other segments:- ischium 1, merus 2, carpus 1.6 and propodus 1.2. The exoped reaches beyond middle of merus.

The pereiopods have proportions in length to dactylus as follows:-

| | Ischium | Merus | Carpus | Propodus |
|---|---|---|---|---|
| First pereiopod | 1.2 | 1.7 | 1.5 | 0.9 |
| Second pereiopod | 1.3 | 2.1 | 2.2 | 0.8 |
| Third pereiopod | 1.3 | 2.7 | 3.3 | 0.9 |
| Fourth pereiopod | 1.3 | 2.3 | 3.1 | 1.0 |
| Fifth pereiopod | 1.3 | 2.3 | 2.1 | 1.2 |

Abdomen dorsally carinated on fifty and sixth somites only. Carina of sixth somite ends in an acute spinule, posteriorly. Last pleonic segment is

1.8 times as long as wide at the middle and 1.5 the length of carapace. Telson has the typical structure of the genus, rather shorter than the inner ramus of uropod. Middorsal groove broader towards the posterior end. Telson 3.8 times as long as broad at broadest region and armed with three pairs of lateral spines. First of these spines situated at middle of telson, second at two-fifth and last at one-third from tip. Proximal two pairs are simple and movable while last pair have articulating tips. Distal end terminates in a long median spine which is broad in middle, narrow at base and pointed at tip.

Thelycum consists of an anterior and a posterior plates between the bases of fourth and fifth legs and a pair of lateral elivated plates disposed parallel to the longitudinal axis. Anterior plate is in the form of a forwardly directed conical process, as long as wide at base, with a slight constriction at about its middle where bases of fourth legs are in close proximity to it. Posterior plate also has an acute projection in the midventral line between posterior end of the lateral plates and set close to the anterior edge of the last thoracic sternite. Lateral plates are concave towards inner aspect and with convex outer surface, extending from base of anterior median prominence to that of posterior one. These plates have pointed anterior ends and rounded posterior extremities.

Petasma of the allotype male is 2.3 times as long as broad, maximum breadth being near distal end. Distomedian projections longer than broad, narrow and thin near the tip and broader at the middle. Proximolateral projections diverge from the base, being twice as long as wide and with maximum width at the middle. Paired distolateral projections between distomedian and proximolateral projections are short, about half the length of distolateral ones and provided with pointed tips.

Appendix masculina has a distal piece considerably enlarged, more or less ovoid, 1.3 times as long as wide, greatest width being across the middle. Basal piece is enlarged, 1.5 times the length of distal piece and 1.8 times as long as broad.

Cardiac plate bears twentyseven spinules arranged in a single row near the posterior end and irregularly disposed towards the other end of the plate. Zygocardiac ossicle has an upper row of three rudimentary teeth and a lower set of well developed, sharp and pointed teeth. Urocardiac ossicle flat anteriorly with large processes ending in pointed laterally directed apices. Prepyloric has a median tooth with rounded apex and a row of eight to nine teeth on either side decreasing in size towards the sides.

Specimens preserved in neutralised 5% formaldehyde are [illegible] coloured, becoming brownish on prolonged storage.

Distribution: Known only from the type locality, western lagoon of Minicoy Island, Laccadive Archipelago.

The type specimens are deposited in the reference collection museum of the Central Marine Fisheries Research Institute, Mandapam Camp. Holotype, female - CMFRI No.197; Allotype, male _ CMFRI No.164.

Discussion: The genus Trachypenaeopsis Burkenroad is represented by only two species, viz., T. richtersii (Miers, 1884) from the Indo-Pacific and T. mobilispinis (Rathbun) 1919) from the Antilles. The present material was collected from the shallow waters of the western lagoon of Minicoy Island, Laccadive Archipelago. These prawns were found to belong to Trachypenaeopsis but differed from the two known species and hence are here described as new. This is also the first report of the genus from the Indian Region (between 60°E and 90°E and north of equator).

Rathbun (1934) created the genus Trachypenaeopsis to accommodate the two species known at that time, viz. Metapenaeus nobilispinis Rathbun, 1919 from the Dutch West Indies and Bahamas, Atlantic Ocean and Penaeus richtersii Miers, 1884 from Cerf Island, Western Indian Ocean and Hawaii Islands, Pacific Ocean. These species were for a long time mistakenly ascribed to the genera Penaeopsis and Metapenaeus due to their superficial resemblance. However, the absence of pleurobranch on the thirteenth somite and the unfurcate epipods distinguish them from species of both the above genera. Besides, these differ from Penaeopsis in the lack of a parapenaeid spine and the paired fixed teeth distal to the movable lateral spines of the telson, while the presence of epipods on the fifth legs and the absence of spines on basipods of second and third chelipods separate them from Metapenaeus. The genus Trachypenaeopsis is closely related to Atypopenaeus although it differs in the nature of the antennal spines, short antennular flagella, armature of telson, peculiar petasma and unfurcate epipods. The last-mentioned character is unique in this genus, as in all known adult penaeids the epipods are bifurcate.

The present species exhibits close resemblance to the other known species viz. Trachypenaeopsis richtersii (Miers) and T. nobilispinis (Rathbun) in general organisation. But the petasma of T. miniocyensis is strikingly different from those of the other two species. There are three pairs of distal projections, as in T. nobilispinis, of which the anteromedian ones are the longest and the distolaterals the shortest. But, in T. nobilispinis the size of these projections increases from the proximal to the distal ones while in T. richtersii the only pair of lateral projections is longer than the other. The additional projections mentioned by Rathbun (1906) are not shown in her

figure of the dorsal view of petasma. Such a pair, if present in the material, should have been visible in the dorsal view. Therefore, it is quite probable that these ocurrs, as pointed by Ruttenroad (1954). Thus T. mobiliensis shows more affinity to the present species than T. Richtersii, in the structure of the petasma.

The telson of T. miniocrensis resembles that of T. mobiliensis in that the distalmost pair of movable spines has articulating extremities, which are not well defined in T. richtersii. Besides, the tip of the telson has a constriction at the level of the bases of the distalmost pair of spines. There are two notches at the bases of telson on the dorsal side in T. mobiliensis whereas the notch is single and medium in T. miniocrensis.

In addition to these differences there are other less important dissimilarities between the present species and other two. Thus the median anterior elevation of the anterior thelycal plate in T. richtersii is slender, five ~~FIVE~~ times as long as wide, while in T. miniocrensis it is stout and about as long as wide. The well developed epipods and endites of first maxillipeds of T. miniocrensis are absent in T. richtersii.

Genus Metapenaeopsis Bouvier (1905)

Key to Indian species of Metapenaeopsis

1. Stridulating organ present on posterior branchiostegite ... 2
- Stridulating organ absent from posterior branchiostegite ... 3
2. Dorsal carina of 3rd pleonic somite sulcate; stridulating organ almost straight; anterior edge of thelycum plate entire, left petasmal lobe sharply pointed and triangular. .. M. stridulans (Alcock)

- Dorsal carina of 3rd pleonic somite flat or hardly sulcate; thelycal plate about as wide as long; left petasmal lobe with processes arranged in a semicircular manner; inner intermediate strip much longer than outer. .. .. M. barbata (de Man)

3. A pair of tooth-like platelets behind thelycal plate, posterior tubercles absent; distoventral projection of petasma with a terminal filament; third abdominal carina sulcate. .. M. gordonensis (Kathiran)

- A pair of leaf-like platelets behind the thelycal plate, distoventral projections of petasma without terminal filament; groove on the third abdominal carina absent. .. .. .. .. M. hilgendi (de Man)

- No toothe-like platelets immediately posterior to thelycal plate. 4

4. Sternum of female 2nd pereopods with 2 long spinous processes; hepatic sulcus descending almost vertically to ventral edge of branchiostegite. ... ... ... M. borradaili (de Man)

- Hepatic sulcus absent, or not reaching to ventral edge of branchiostegite. .. .. .. 5

5. Rostrum as long as or longer than antennular peduncle. .. 6

- Rostrum not reaching tip of antennular peduncle; centre of thelycal plate non-sulcate. .. .. M. coniger (Wood-Mason)

6. Posterior extension of thelycal plate with distinct median sulcus and rounded posterolateral corners. .. M. philippi (Bate)

- Posterior extension of thelycal plate with indistinct median sulcus and angular posterolateral corners. M. andamanensis (Wood-Mason)

Only three species of the genus are reported in the present account.

## Metapenaeopsis stridulans (Alcock, 1905)

Metapenaeus stridulans Alcock, 1905:526; 1906:27-29; (not synonymy, nor figure 14b, pl.5); Borradaile 1910:257.

Metapenaeopsis stridulans Nataraj, 1942:468; Hall, 1961:105-109; 1962:32; 1966:99; de Bruin, 1965:84-85; Rack and Dall, 1965: 32-34; George, 1969:25.

Metapenaeopsis novae-guineae Kunju, 1960:83;

Penaeopsis stridulans de Man, 1911:65-69; Tattersal, 1921:266.

Material: Several specimens. Bombay (28-10-67) 4 males, carapace length 11.3 - 16 mm; 8 females, 15.2 - 18.4 mm; Off Pudumadam, Gulf of Mannar (29-12-67) 5 males, 12 - 12.5 mm; 4 females, 11 - 15 mm; (1-2-69) 5 males, 10.8 - 12 mm; 1 female, 10 mm; Vedalai, Gulf of Mannar (29-4-67) 35 males, 10.75 - 10.9 mm; 10 females, 10.8 - 13.2 mm; (19-2-66) 1 male, 10.3 mm; 1 female, 10.2 mm; (9-5-68) 5 males, 9 - 11.5 mm; 9 females, 8.2 - 13.2 mm; Mandapam, Gulf of Mannar (14-1-70) 6 males, 10 - 15 mm; 7 females, 12 - 19 mm; Rameswaram (23-9-69) 2 males, 11.8, 13 mm; 1 female, 13 mm; (5-6-68) several males, 11.5 - 12 mm; 1 female, 12.6 mm; Thangachimadam, Palk Bay (13-9-66) 3 males, 10 - 13.4 mm; 1 female, 11.2 mm; (24-5-67) 1 male, 10 mm; 1 female 10.9 mm; (11-7-67) 1 male, 11.5 mm; 6 females, 11.1 - 15 mm; Nagapattinam (20-5-69) 1 male, 11 mm; 2 females, 9.7 , 10.8 mm; Kakinada (5-12-68) 2 males, 9.5, 13 mm; 3 females, 12 - 13.7 mm.

Discussion: This specie which resembles. M. novae-guineae closely can be easily distinguished by the arrangement of the stridulating ridges on the posterior end of the carapace. In M. stridulans the ridges are wider and lesser in number (6) being arranged in a straight line and decreasing in size

from the posterior end. But in M. arcuo-cuinese these ridges vary in number from 11 to 17 and are arranged in an arch descending from the middle to almost 1/6 depth of carapace (Roock and Dall, 1965, Fig.2,A).

In the general morphology, the specimens at hand agree well with earlier descriptions although certain minor difference are noticed in the structure of the petasma. In large specimens (c.l.14.2 mm) the distal end of the left disto-ventral projections bears four long finger shaped processes on the outer aspect while the 8-9 shorter processes on the inner margin decrease in size from the distal to the proximal end. But in younger specimens (c.l.9.5 mm) the outer processes are very short while the inner ones are in the form of small granules. The inner intermediate strip, in larger ones, is elongated with narrower tip while in younger specimens it is broader and of more or less uniform width throughout its length.

Distribution: Red Sea (Tattersal,1921); east coast of Africa (Hall, 1966); Indian Ocean (Borradaile, 1910); west coast of India (Nataraj, 1942; Kunju, 1960; George, 1969); Ceylon (de Bruin, 1965); east coast of India (Alcock, 1906); Gulf of Martaban (Alcock, 1906); Andamans (Alcock, 1906); Singapore (Hall, 1961; 1962; 1969); Hong Kong (Alcock, 1906); East Indies (Alcock, 1906); Australia (Roock and Dall, 1965).

Metapenaeopsis borradailei (de Man 1911)

(Pl.I, 14-20)

Penaeopsis borradailei de Man, 1911:73-75, pl.8, fig.24 a, b.

Metapenaeopsis borradailei Dall, 1957, 1957:174-176, fig.13 A - E.

Metapenaeopsis borradailli Roock and Dall, 1965:20(Key); Thomas, 1972:

213-216.

Material: 30 specimens. Minicoy Island (21-7-67), 12 males, carapace length 5-7 mm; 6 females, 6-10 mm; Chetlat Island (21-7-67) 2 males, 6, 6.5mm; 2 females, 7, 8 mm; Kalpeni Island (25-5-65) 1 male, 7 mm; Kavaratthi Island (22-12-68) 1 male, 7 mm; 3 females, 9-10 mm. Collected by Sri M. Ali Manikfan, from the coral reef area and the Bay of the Islands. Depth of occurrence: 1-3 m.

Discussion: Metapenaeopsis borradaili can be easily distinguished by the distinctive petasma, the possession of distal segment of appendix masculina, the presence of a single median pointed spine between the bases of the fourth pair of coxae and the paired subrectangular plates situated posterior to this spine. Besides, the nature of hepatic sulcus and absence of dorsal carina on the abdomen anterior to the fifth somite are other characters of taxonomic importance. The present material agrees with the description given by Dall (1957). But, in some details of structure there are certain differences.

The specimens from the Laccadive Archipelago have straight, upturned rostrum with 9 teeth and the epigastric tooth, reaching only to the middle of the first antennular segment, while in the Australian form it reaches the tip of the second segment of antennular peduncle.

The antennal carina does not extend beyond the base of the antennal spine. The upper flagellum of the antennule is shorter than the lower, 1/3 as long as the peduncle and only less than 1/4 the carapace length, unlike that of the Australian forms. The prosartema is 1/2 the long axis of the cornea and as long as the stylocerite. The third pereiopod reaches only to the base of second segment of the antennular peduncle.

The fifth and sixth abdominal segments only have the dorsal carina which end posteriorly in a spinule. The sixth segment is 1.5 times as long as wide. The telson is 4 times as long as broad and bears four pairs of lateral

spines. The proximal of these is small and placed at half the length of the telson. The second pair which is longer and slender is situated at half the distance from the tip of the telson to the proximal pair, and the next pair which is the longest is nearly 5 times the length of the next proximal one. The distalmost spines are 3/5 the length of the penultimate pair of spines and situated at the base of the apical spine, Dall's specimen is reported to have only three movable spines on either side of the telson. The cardiac plate has 22 spinules. The zygocardiac ossicle is provided with five stout teeth, of which three are in upper and two in lower rows, followed by a series of slender spinules. The prepyloric ossicle has a large median tooth and a series of 5-6 small teeth on either side.

The structure of the petasma of the present males differs from that described from Australia by Dall. The distolateral projections are large, much expanded and overhanging dorsally over the apex of the petasma. The left distoventral projections are highly reduced. The distodorsal lobules are well developed. The distomedian lobules are bifid as in Dall's specimen, reaching the base of the third pereopods and bear minute setae at the distal end. The distal segment of the appendix masculina in M. borradailli from Laccadives is 1/4 the basal segment while in the Australian specimen it is only 1/8 in length. The structure of the thelycum agrees well with the Bibega specimens described and figured by de Man (1911). The median processes of the anterior thelycal plate is well developed. The paired posterior plates have a little wider groove in between. The paired processes situated between the bases of the second pair of pereopods are more slender, elongated and separate at the base.

Distribution: East Indies (de Man 1911); Torres Strait (Dall, 1957); Laccadive Archipelago (Thomas, 1972).

## Metapenaeopsis hilgendorfi (de Man 1911)

(Pl.II, 1-3)

Penaeopsis sp. (hilgendorfi) de Man 1911:70,71, pl.7, fig.22.

Penaeopsis hilgendorfi Barnard 1950:595, fig.108g-i.

Metapenaeopsis mogiensis Hall, 1962:35, fig.120; Rack and Dall, 1965: 42-44.

Metapenaeopsis hilgendorfi de Bruin, 1965:81-82, fig.1b, d; Mathai, 1972: 150, figs.7-10.

Material: 20 specimens. Off Pudumadam, Gulf of Mannar (1-2-69) 1 male carapace length 10 mm; Vedalai, Gulf of Mannar (29-4-67) 2 males, 8, 8.2 mm; 2 females, 7, 9 mm; (9-5-68) 1 female 8.1 mm; (30-1-69) 1 male, 8.3 mm; 2 females, 10, 12 mm; Marukayarpattinam, Gulf of Mannar (22-2-68) 1 female, 14 mm; (31-1-69) 5 males, 3.5 - 12.5 mm; 5 females, 9.5 - 10.5 mm. Collected from shore seine and trawl net catches. Depth of occurrence: 2 - 15 m.

Discussion: The specimens on hand agree with the specimens described by de Bruin (1965) as M. hilgendorfi, although this species was confused with M. mogiensis by Hall (1962). Barnard's (1950) description and figures of thelycum, petasma, appendix masculina and inner antennular flagellum agree with the specimens collected during the present study. De Bruin (op.cit.) has given the resemblances and differences between this species and M. mogiensis. The present material from Gulf of Mannar and Palk Bay resembles M. mogiensis in the nature and the length of the rostrum, ratio between carapace length and antennular flagellum, position of the epigastric tooth, ratio of the length and breadth of 6th abdominal segment and presence of paired spines between the bases of the 2nd pereopods in females. But they differ from M. mogiensis in the absence of the terminal filaments on the left distroventral projection

of petasma, absence of groove on the third abdominal carina, the well developed paired processes between the bases of the 4th pair of pereopods and the only pair of lateral processes on the sternum of the female, between the bases of the 5th pair of pereopods. From the fact that these characters are well developed in specimens of small and large sizes, it is clear that the differences are not due to the difference in the age of the prawns as suggested by Dall (1957).

Distribution: East Indies (de Man 1911); Singapore (Hall, 1962); South Africa (Barnard, 1950); Gulf of Mannar, Ceylon (de Bruin, 1965); east coast of India (Mathu, 1972).

Genus Metapenaeus Wood-Mason and Alcock 1891

Key to the Indian species of Metapenaeus

1. Distomedian petasmal projection with fully developed or vestigial apical filament; thelycum of impregnated females usually with white conjoined pads. .. .. .. .. 2

- Distomedian petasmal projection without apical filament; thelycum of impregnated females without white conjoined pads. .. 4

2. Rostrum wide and short, not reaching to distal end of basal antennular segment; thelycum with ovoid anterior and lateral plates of subequal size; conjoined pads usually set askew; apical filaments of petasma vestigial represented by a pair of rounded bosses. .. .. .. M. lysianassa (de Man)

- Rostrum projecting beyond basal antennular segment, with a marked edentate distal portion. .. .. .. 3

3. Posterior part of rostrum with distinctly elevated crest; ventral spine on the male 3rd pereopod simple; apical petasmal filaments slender slightly converging; thelycum with a large anterior and

small lateral plates. .. .. M. brevicornis (Milne-Edwards)

- Posterior part of rostrum without distinctly elevated crest basial spine on male 3rd pereopod long and barbed; apical petasmal filaments not readily visible; anterior thelycal plate tongue-like. .. .. M. dobsoni (Miers)

4. Branchiocardiac sulcus distinct in at least posterior 1/3 carapace; distomedian petasmal projections flap-like. .. .. 5

- Branchiocardiac sulcus almost completely absent; distomedian petasmal projections anteriorly filiform each with a serrate ventral margin. .. .. M. stebbingi (Nobili)

5. Ischial spine on 1st pereopod distinct. .. .. 6

- Ischial spine on 1st pereopod small or absent .. .. 9

6. Distomedian petasmal projections directed anterioad; lateral thelycal plates with raised lateral ridges, each with a posterior inwardly curved triangular plate. .. M. gracilis (de Haan)

- Distomedian petasmal projections directed anterolaterally; anterior thelycal plate tongue-like. .. .. 7

7. Lateral thelycal plates with parallel ear-shaped lateral ridges; distomedian petasmal projections hood-like. .. M. monoceros (Fabricius)

- Lateral thelycal plates without lateral raised ridges, distomedian petasmal projections not hood-like. .. .. 8

8. Posterior extension of the anterior median thelycal plate bound laterally by an oval flat plate on each side; distomedian petasmal projections overlying lateral projections and distally trilobed. ... ... ... M. alcocki (George and Rao)

Posterior extension of the anterior median thelycal plate not bound laterally by oval plate on either side; distomedian petasmal

projections not overlying lateral projections. .. ..

.. .. .. M. kutchensis George, George and Rao.

9. Branchiocardiac carina distinct, extending from posterior margin of carapace almost to hepatic spine; anterior thelycal plate longitudinally grooved, wider posteriorly than anteriorly; distomedian petasmal projections crescent shaped. M. affinis (Milne-Edwards)

- Branchiocardiac carina feeble or ill-defined, anterior end not exceeding posterior 1/3 of carapace; distal margin of anterior thelycal plate convex to indistinctly triangular; petasma with laminose and strongly diverging distomedian projections. M.burkenroadi Kubo

The genus Metapenaeus is represented in the present collection by seven species viz. M. lysianassa, M. brevicornis, M. dobsoni, M. ensis, M. monoceros, M. affinis and M. burkenroadi.

Metapenaeus lysianassa (de Man 1888)

(Pl.VIII, 4)

Penaeus lysianassa de Man, 1888:290-295, pl.19, fig.I.

Metapenaeus lysianassa Alcock, 1906:23-24.

Metapenaeus lysianassa Burkenroad, 1934b:36; Kubo, 1949:359-361; Hall, 1956:82-83; 1962:24; Ahmed, 1957; Dall, 1957:103(Key); de Bruin, 1965:81; Racek and Dall, 1965:79-80; Johnson, 1965:7.

Material: 21 specimens. Marakayarpattinam, Gulf of Mannar (30-12-67), 9 males, carapace length, 9.9 - 12.2 mm; 8 females, 10.1 - 12.5 mm; Mandapam, Gulf of Mannar (25-4-68) 1 impregnated female, 16 mm; Nagapattinam (20-5-69) 1 male, 10.1 mm; 2 females 8.5, 9.4 mm; Kakinada (18-4-68) 2 females, 9.2, 11.9 mm. Collected from shore seine, boat seine and trawl net catches. Depth of occurrence [illegible] m.

Remarks: The specimens collected during the present study agree well with the original description of de Man (1888) and Alcock (1906). The petasma of the present specimens also possess stumpy prominences on the ventral posteromedian corner of the disto-median projections as in the case of specimens examined by Racek and Dall (1965) from North Borneo.

The colour of fresh specimen whitish with scattered brown and yellow chromatophores. A few yellowish red spots on the dorsal side of the anterior portion of carapace on either side of the base of rostrum. Antennular flagella reddish at the tips and bases having red spots. Dorsal carina of 6th abdominal segment and margin of uropods and telson, reddish. Uropods and telson with brown and red spots. Other legs and setae whitish.

Distribution: Indian Ocean (Borradile, 1910); east coast of India (Ahmed, 1957; George, 1969); Ceylon (de Bruin, 1965); Malaya (Johnson, 1965); Singapore (Hall, 1956, 1962); East Indies (Racek and Dall, 1965); Japan (Kubo, 1949).

*Metapenaeus brevicornis* (H.Milne Edwards, 1837)

(Pl.VIII, 5)

*Penaeus brevicornis* H. Milne Edwards, 1837:417; Bate, 1881:180; Henderson, 1893:450; de Man, 1897:681; Lanchester, 1901:571.

*Metapenaeus brevicornis* Alcock, 1906:22-23.

*Penaeopsis brevicornis* Kemp, 1918:294-295.

*Metapenaeus brevicornis* Burkenroad, 1934b:33-36; Kubo, 1949:351-355; Hall, 1956:81; 1962:24-25; Menon, 1956:346(Key); Ahmed, 1957; Dall, 1957:185 (Key); Racek and Dall, 1965:81-82; George, 1967; 1969a:28; 1969b: 119-125, fig.15; Tirmizi, 1969:758; Jones, 1969: 743.

Penaeus aviculatus Dana, 1852:603; Heller, 1865:123; Miers, 1880:457.

Penaeopsis aviculatus Bates, 1914:10.

Metapenaeus aviculatus Nobili, 1903:2.

Penaeus sp. Lanchester, 1901:571-572.

Material: 16 specimens. Bombay (12-11-67) 1 male, carapace length 17.2 mm; 2 females, 23.5, 24.9 mm; Adirampattinam (28-9-68) 8 males, 11.5 - 13.1 mm; 15 females, 11.4 - 18.5 mm. Collected from trawl catches. Depth of occurrence: 15 - 30 m.

Discussion: The material examined during the present studies conforms with the descriptions given by the earlier workers. The ischial spines on the Ist pair of pereopods are well defined. The distal pair of spines and the lateral spines are clearly perceptible on the telson.

The species is easily distinguishable from the other Indian species of Metapenaeus by the shape of the rostrum. Its distribution is restricted to the northern part of the both west and east coasts of India. The juveniles form fishery in the large estuarine systems of the rivers of North India.

Distribution: West coast of India (Henderson, 1893; Alcock, 1906; Tirumal, 1969); east coast of India (Henderson, 1893; Alcock, 1906); Gulf of Martaban (Alcock, 1906); Malaysia (Alcock, 1906; Miers, 1880; Lanchester, 1901; Kemp, 1918; Rack and Dall, 1965); Singapore (Hall, 1956; 1962; Dana, 1962); East Indies (de Man, 1897; Rack and Dall, 1965); Japan (Kubo, 1949).

Metapenaeus dobsoni (Miers 1878) (Pl.VIII, 6)

Penaeus dobsoni Miers, 1878:302-304.

Penaeopsis dobsoni Kemp, 1915:322; Panikkar, 1937; Johnson, 1965:321-322.

Penaeopsis sp. de Man, 1911:60-61.

Metapenaeus dobsoni Alcock, 1906:21-22.

Metapenaeus dobsoni Nibili, 1905:3; Hatanaj, 1942:468; Kurian, 1955: 761; Menon, 1956:546(Key); Dall, 1957:183(Key); Hall, 1962:23; de Bruin:1965:80; Knock and Dall, 1965:80-85; Johnson, 1965:7; George, 1967:1-15, figs. 1-13; 1969a:77-95; 29; figs.7-10; Jones, 1969:741.

Materials: Several specimens. Mangalore (19-1-68) 7 males, carapace length, 15.2 - 17.5 mm; 4 females, 20.3 - 22.2 mm; Koshikode (6-11-66) several males, 23 - 27 mm; several females, 26 - 36 mm including many impregnated females with white pad covering the thelycum; Korapuzha (12-12-66) males, 11.2 - 18.5 mm; females, 13.1 - 19.4 mm; Cochin (18-12-69) 2 males, 16.2, 15.3 mm; 1 female, 20.9 mm; (10-6-67) 5 females 10 - 13 mm; Kilakkarai (21-12-67) 2 males, 15, 19 mm; 6 females, 12 - 20.2 mm; (29-12-67) 1 male, 14.6 mm; 1 female, 18.8 mm; Pulicat Lake Creek, Palk Bay (2-5-67) several juveniles 8.5 - 10 mm; Madras (24-8-67) 2 males, 10.5, 12 mm; 6 females, 7.5 - 44(?) mm; Kakinada (18-4-68) 1 male 17.2 mm; 1 female, 18.4 mm; Bhurine Bay, Andamans (28-8-67) 3 males, 9.5 - 11.2 mm. Collected from trawl net and stake net catches. Depth of occurrence: 2 - 25 m.

Discussion: The material on hand is in full agreement with the previous descriptions of the species. The free filament of the distomedian projection of the petasma on the dorsal side, are well developed in the adult specimens obtained from Palk Bay and Gulf of Mannar as noticed by Knock and Dall (op.cit.) The impregnated females have the conjoined white pads on the thelycum as in M. brevicornis.

M. dobsoni is one of the most commercially important species on the southwest coast where it is fished in large qualities by the mechanised boats and indigenous craft and gear from the sea while the stake net catches

of the estuaries and backwaters contain considerable quantities of the juveniles and even mature specimens. This species enter these waters and grow to maturity when they return to sea for spawning as in the case of most of the other penaeid prawns.

Distribution: West coast of India (Miers, 1878; Nataraj, 1942; Khuraij, 1953; George, 1969); Ceylon (de Bruin, 1965); east coast of India (Kemp, 1915; Panikkar, 1937); Singapore (Hall, 1962); Malaysia (Johnson, 1965; Racek and Dall, 1965); East Indies (Racek and Dall, 1965).

Metapenaeus ensis (de Haan, 1850)

Penaeus monoceros ensis de Haan, 1850:192.

Penaeus monoceros Haswell, 1882:200.

Penaeus mastersii Haswell, 1879:42; 1882:203.

Penaeus incisipes Bate, 1888:257-258 (not including female); Kishinouye, 1900:18-19; Blanco and Arriola, 1937:223.

Penaeopsis monoceros de Man, 1911:55-57; Schmitt, 1926:325-329 (including part of 'Penaeus mastersii')

Metapenaeus incisipes Alcock, 1906:51

Metapenaeus ensis Alcock, 1906:24-25.

Metapenaeus monoceros Kubo, 1949:329-333 (part synonymy only); Hall, 1956:77-78 (not including Fig.11); Dall, 1957:184-187 (part synonymy only)

Metapenaeus incisipes Racek, 1955:230-232; 1959:10.

Metapenaeus ensis Hall, 1950:537-544; 1962:22-23; Cheung, 1960:66; Racek and Dall, 1965:58-61; de Bruin, 1965:80; Muthu, 1967:465; George, 1969:29-30.

Material: 4 specimens. Kakinada (18-6-69) 2 males, carapace length 23.6 mm, 24 mm; 2 females, 27.3, 31 mm. Collected from trawl catches. Depth of occurrence: 20 - 40 m.

Discussion: Close examination of the material on hand has shown that they agree well with the descriptions given by earlier workers including Mathu (1967) who collected his material from Orissa coast. The distomedian lobes of the petasma are pointed forwards and not laterally, as in M. monoceros. The outside margins of lateral thelycal plates are arched towards the midline on the posterior end. Median lobe of the thelycum is broader anteriorly and with prominent lateral ridges enclosing a wide shallow groove. Besides, curved spine on the merus of male is less prominent and more inclined than in the male of M. monoceros of same size. The recent reports of the species from East coast of India (Mathu, 1967) and Ceylon (de Bruin, 1965) have proved that the distribution of the species is not restricted to the east of the Malayan Peninsula/Sumatra land-mass as suggested by Hall (1956-1962).

Distribution: East coast of India (Mathu, 1967; George, 1969); Ceylon (de Bruin, 1965); Andamans (Alcock, 1906); Singapore (Hall, 1956; 1958;1962); East Indies (de Man, 1911); Philippines (Bate, 1888; Blanco and Apiola, 1957); Hong Kong (Cheung, 1960); Japan (de Haan, 1850; Kubo, 1949); Australia (Haswell, 1879; 1882; Kishinouye, 1900; Schmitt, 1926; Dall, 1957; Knock and Dall, 1965).

Metapenaeus monoceros (Fabricius, 1798) (Pl.IX, 1)

Penaeus monoceros Fabricius, 1798:409; Milne Edwards, 1837:415; Dana, 1852:605; Stimpson, 1860:44 (part); Miers, 1878:301; Bate, 1818:177; Ortmann, 1890:450 (part); Thallwitz, 1890:91-92; de Man 1892:313; 1897:680; Doflein,1902:651.

*Metapenaeus monoceros* Alcock, 1906:18-20.

*Penaeopsis monoceros* Kemp, 1915:321; Calman, 1925:12; Monod, 1930:140; Panikkar, 1937:345; Panikkar and Aiyar 1937:295; 1939:354.

*Penaeopsis spinulicauda* Stebbing, 1914:17; 1917:44.

*Metapenaeus monoceros* Nobili, 1903:3; Burkenroad, 1934b:32-33; Matsuai, 1942:468; Barnard, 1950:597-599; Menon, 1956:346 (Key); Ahmed, 1957:9; Hall, 1958:543; Racek and Dall, 1965:57 (Key); de Bruin, 1965:79-80; Joubert, 1965:27-29; Joubert and Davies, 1966:10-31; Hall, 1966:98; Tirumai, 1969:760; George, 1969a:96-107; 1969b:30-31; Jones, 1969:741.

Material: Several specimens. Bombay (12-11-67) 2 females, 28.5, 28.6 mm; Vembanad Lake, Kerala (10-6-67) 4 males, carapace length, 16 - 20.5 mm; 10 females, 13.8 - 18.5 mm; Pallimadam Creek, Palk Bay (2-3-67) 11 females, 9.8 - 19.5 mm; Kakinada (18-4-68) 28 males, 16.5 - 22.5 mm; 34 females, 17.25 - 27 mm. Collected from stake net catches. Depth of occurrence 1-6 m.

Discussion: The juveniles and adults agree with the previous descriptions. On the west coast this species, especially juveniles, constitutes a good proportion of the prawn catches by stake nets in the estuaries and backwaters.

Distribution: West coast of India (Matsuai, 1942; Chopra, 1943; George, 1959, 1969; Tirumai, 1969; Rao, 1969); Ceylon (Nicoe, 1878; de Bruin, 1965); east coast of India (Panikkar, 1937, Panikkar and Aiyar, 1937, 1939; Ahmed, 1957; Rao, 1969); Malaya (Nicoe, 1878; Kemp, 1918); Singapore (Dana, 1852; Hall, 1958, 1966); South Africa (Stebbing, 1914, 1917; Calman, 1925; Monod, 1930; Barnard, 1950; Joubert, 1965; Joubert and Davies, 1966).

## Metapenaeus affinis (Milne Edwards, 1837)

(Pl.IX, 2)

Penaeus affinis H.Milne Edwards, 1837:416; Miers, 1878:304; Lanchester, 1901:304.

Penaeopsis affinis, Kemp, 1915:321; 1918:294; de Man, 1924:4-5 (non 1911); Panikkar, 1937:345; Johnson, 1965:321.

Penaeus mutatus Lanchester, 1902:572-573.

Metapenaeus affinis Alcock, 1906:20-21.

Metapenaeus affinis Burkenroad, 1934:29-32; Kubo, 1954:89-93 (non 1949); Menon, 1956:346(Key); Dall, 1957:182(Key); Cheung, 1960: 66; Rnock and Dall, 1965:68-69; Tirmizi, 1969:758,760, figs.5, A-D; George, 1967:1-13, fig.1; 1969a:31-32; 1969b:107-117, figs.13,14; Jones, 1969:741.

Metapenaeus neoopinens Hall, 1956:82-84.

Metapenaeus mutatus Hall, 1961:86-87; 1962:25; de Bruin, 1965:76-78.

Material: Several specimens. Bombay (13-11-67) 3 males, carapace length 24.75 - 28.1 mm; 2 females, 30, 33 mm; Mandapam, Palk Bay (13-4-67) 1 female, 42 mm; Adirampattinam (28-9-68) 1 male, 15.9 mm; 1 female, 13 mm; Marine Bay, Andamans (6-8-67) several juvenile specimens, males, 10.32 - 15.1 mm; females, 9.9 - 14.8 mm; (2-8-67) 1 male, 17.4 mm; 1 female, 15 mm.

Discussion: The distinguishing characters of the species are well defined in the materials examined. In spite of the recent differences of opinion regarding the taxonomic status of this species from Indian waters it is felt that the view of Rnock and Dall (op.cit.) considering M. neoopinens and M. mutatus of Hall (1956 and 1961) as synonyms of M. affinis is more reasonable.

M. affinis has been found in the trawl catches from Palk Bay during the months of March to October in small quantities. This medium sized prawn is of great commercial importance along the coast of India being fished more from the sea, although small amounts are caught from the estuaries and backwaters.

Distribution: West coast of India (Tirumini, 1969; Kurian, 1953; George, 1969); Gulf of Suez (Miers, 1878); east coast of India (Pannikar, 1937); Ceylon (de Bruin, 1965); Malaya (Lanchester, 1901; Hall, 1956; 1961; 1962; Johnson, 1965); Hong Kong (Cheung, 1960); Japan (Kubo, 1954); Australia (Racek and Dall, 1965).

Metapenaeus burkenroadi Kubo 1954

(Pl.III, 14-22; IX, 3)

Metapenaeus burkenroadi Kubo, 1954:92-93; Dall, 1957:183(Key); Racek, 1957:6-7; Cheung, 1960:66, 68; George, 1964: 313-314; de Bruin, 1965:78-79; Racek and Dall, 1965:72-75.

Penaeopsis affinis Bates, 1914:7; 1942:44(non de Man, 1911).

Penaeus affinis Kishinoye, 1900:16-18.

Parapenaeus affinis Rathbun, 1902:38.

Metapenaeus affinis Nataraj, 1942:468; Kubo, 1949:340-344.

Metapenaeus monoceros Hall, 1962:23-24 (non Racek, 1955, 1957, 1959; Dall, 1957, 1958).

Material: 12 specimens. Off Pudumadam, Gulf of Mannar (30-11-66) 2 females, carapace length, 16.5, 14.8 mm; Thangachimadam, Palk Bay (11-7-67) 2 males, 12, 12.1 mm; 1 female, 11 mm; Madras (24-8-67) 2 males, 13.5, 13 mm; 3 females, 14.5 - 17.2 mm; Marine Bay, Andamans (2-8-67) 1 male, 11.1 mm; 1 female, 13.8 mm.

Discussion: The specimens collected during the present studies show all distinguishing characters of the species given in the original description (Kubo, op.cit.) as well as by subsequent workers. But the variations found in the Ceylon specimens by de Bruin (op.cit.) were also noticed in the present material from Palk Bay and Gulf of Mannar. The distances between the rostral teeth were quite variable. Similarly the pubescens on the dorsal surface of the carapace was more prominent in females than in males. Females had first four and the last two abdominal segments less glabrous than males eventhough in both the sexes the fifth and sixth segments were more pubescent than the preceeding segment.

The thelycal plates are flat with slightly raised outer margins. The lateral horns bear long setae while the plates are glabrous. The distomedian projections of the petasma are laminate and divergent.

The species is common in the Athankarai Estuary, where it is more numerous during summer when salinity of the water is greater due to the drying up of the rivermouth. This is in agreement with the finding of de Bruin, although, contrary to his report this species is caught in less numbers from the sea from depths ranging from 2 - 15 m.

M. kuskensvaldi is common in Palk Bay and Gulf of Mannar although, it was only recently recorded from Indian waters, (George, 1964).

Distribution: West coast of India (Nataraj, 1942; George, 1964); Ceylon (de Bruin, 1965); Singapore (Hall, 1962); Hong Kong (Cheung, 1960); Japan (Kishinouye, 1900; Rathbun, 1902; Kubo, 1949); Australia (Racek, 1957; Racek and Dall, 1965).

This is the first report of the species from the east coast of India.

## Genus *Trachypenaeus* Alcock 1901

### Key to Indian species of *Trachypenaeus*

1. Epipodites present on 1st and 2nd pereopods. .. .. 2

   Epipodites absent on 1st and 2nd pereopods; distolateral projections of petasma with sharp tips reaching coxae of 4th pereopods; anterolaterally with large wing-like flaps on outer curvature. .. .. *Trachypenaeus pescadoresensis* Schmitt

2. The plates of thelycum with raised anterior and lateral margins. .. .. *Trachypenaeus sedili* Hall

   The anterior plate of the thelycum may have a raised anterior margin but laterally the margins are not raised; an excavation present between the anterior plate and the transverse sternal ridge. .. .. *Trachypenaeus curvirostris* (Stimpson)

There are three species of the genus *Trachypenaeus* collected during the present investigations, viz. *T. pescadoresensis*, *T. sedili*, and *T. curvirostris*.

*Trachypenaeus pescadoresensis* Schmitt, 1931

(Pl.II, 4,5,9,10; IX, 4)

*Trachypenaeus pescadoresensis* Schmitt, 1931:265-268; Hall, 1962:29; Cheung, 1960:65(Key).

*Trachypenaeus pescadoresensis* Mohamed, 1969:30; George, 1969:33; Thomas, 1971:192.

*Trachypenaeus granulosus* Hall, 1961:100.

*Trachypenaeus furcilla* Hall, 1961:102-104.

Material: Several specimens. Rameswaram (11-8-67) 4 females, carapace length, 20-22 mm; Thangachimadam, Palk Bay (11-5-68) 6 males, 11 - 13 mm; 7 females, 11 - 16 mm; Vedalai, Gulf of Mannar (20-12-67) 6 males, 10 - 12 mm; 3 females, 12 - 13 mm; Mandapam, Gulf of Mannar (30-10-68) 1 male, 12 mm; 8 females, 16 - 21 mm. Collected from trawl net, boat seine and shore seine catches of night fishing operations. Depth of occurrence: 2 - 12 m.

Discussion: Trachypenaeus pseudocrassis Schmitt is closely related to Trachypenaeus granulosus (Haswell), though it differs from it in the structure of the thelycum and petasma. Unlike that of T. granulosus the anterior thelycal plate in T. pseudocrassis does not reach the posterior margin of the posterior plate. The outer expansion of the petasma is conspicuous and wing-like. The appendix masculina has a series of spinules on the distal and distolateral aspects of the distal piece whereas in T. granulosus from Australia (Dall, op.cit) the spinulesare only present at the distal end.

The cardiac plate has 35 - 42 spinules. Zygocardiac ossicle with principal sooth and an upper and lower row of 10 - 15 teeth, each row ending in a cluster of smaller teeth. Propyloric has a medium blunt tooth and a row of fifteen teeth on either side. The distal piece of the appendix masculina is broader anteriorly and fringed with spinules on the distal and distolateral aspects.

Distribution: West coast of India (Mohamed, 1969; George, 1969); south east coast of India (Thomas, 1971); Malaysia (Hall, 1961; 1962); Formosa (Schmitt, 1931); Hong Kong (Cheung, 1960).

*Trachypenaeus sedili* Hall, 1961

*Trachypenaeus sedili* Hall, 1961:100-102; 1962:30; de Bruin, 1965:99-93.

*Trachypenaeus sedili* Rack and Dall, 1965:92; Mahamed, 1969:30; George, 1969:33; Thomas, 1971:192-195; Mathu, 1972:148.

Material: 22 specimens. Rameswaram (22-3-1969) 3 males, carapace length, 8.5 - 9.5 mm; 7 females, 11.5 - 14.5 mm; Mandapam, Gulf of Mannar (8-4-69) 3 males, 10.5 - 11 mm; 9 females, 11 - 19 mm. Collected from trawl catches from muddy bottom during night. Depth of occurrence: 2 - 25 m.

Discussion: The specimens collected during the present study agree well with the descriptions given by Hall (1961), de Bruin (1965) and Thomas (1971). The species can be distinguished from the allid species by the nature of the petasma and the chair-like shape of the thelycum which are well defined in the specimens on hand.

The body colour in live specimen is yellowish white with dark yellow patches as observed by Thomas (*op.cit.*). The posterior margin of carapace is brown as also the rostrum which becomes lighter in shade towards the distal extremity while the antennae are white with yellowish pink flagella. The uropods are dark brown in the middle, margins becoming whitish towards the tips. Telson brownish, distally, bearing yellow setae.

Distribution: Mandapam, Gulf of Mannar and Rameswaram, (Thomas, 1971); east coast of India (Mathu, 1972); Ceylon (de Bruin, 1965); southwest coast of India (George, 1969); Malaya and Singapore (Hall, 1961; 1962).

## Trachypenaeus curvirostris (Stimpson, 1860)

(Pl.II, 7,8,11,12)

Penaeus curvirostris Stimpson, 1860:44; Kishinouye, 1900:23.

Penaeus granulosus Miers, 1884:295.

Penaeus (Trachypenaeus) curvirostris de Man, 1907:436-439.

Parapenaeus curvirostris Rathbun, 1902:38.

Trachypenaeus anchoralis de Man, 1911:88-90; Tattersall, 1921:252, pl.35, fig.1.

Trachypenaeus curvirostris Alcock, 1905:823; Schmitt, 1926:353-358; Hall, 1961:98-100; 1962:29; 1966:99; de Bruin, 1965:92

Trachypenaeus (Trachysalambria) curvirostris Racek, 1955:235-256 (except fig.4, pl.7):1959:10.

Trachypenaeus curvirostris Balss, 1914:11; 1924:24; Ramadan, 1938:63; Kubo, 1949:393-395; Liu, 1955:14-16; Dall, 1967: 203-206; Cheung, 1960:65 (Key); Kunju, 1960:83; Racek and Dall, 1965:89; Cheng-Ming, 1965:13; George, 1969:33-34, Jones, 1969:745.

Material: 8 specimens. Off Pudumadam, Gulf of Mannar (18-3-69) 1 male carapace length, 13 mm; 2 females, 10, 11.5 mm; Off Mandapam, Gulf of Mannar (25-3-69) 3 males, 8 - 14.5 mm; 1 female, 15.5 mm; Minicoy Island (10-1-67) 1 male, 8 mm. Collected from trawl nets from Gulf of Mannar and from shallow waters of Minicoy Island. Depth of occurrence: 10 - 30 m.

Discussion: The species has been well described by previous workers. The material on hand does not afford additional criteria for discussion. Although de Bruin (op.cit.), has pointed out the differences in the nature of the rostru it has been observed that the rostrum exhibits much variation as already remarked by Hall (1961).

The species occurs lesser in number in the trawl catches than its congeners occuring in the Palk Bay and Gulf of Mannar. This species seems to prefer deeper waters as no specimen has been collected so far, from the shore seines although P. pseudomegalops is common.

Distribution: West coast of India (Ramju, 1960; George, 1969); Red Sea (Tattersall, 1921; Ramadan, 1938); Ceylon (de Bruin, 1965); East Indies (de Man, 1911); Singapore (Hall, 1961; 1962; 1966); China (Liu, 1955); Hong Kong (Cheung, 1960); Taiwan (Cheng-Ming, 1965); Japan (Kishinouye, 1900; Rathbun, 1902; de Man 1907; Kubo, 1949; Dall, 1957; Hoek and Dall, 1965).

This is the first report of the species from the Laccadive Archipelago.

Genus Parapenaeopsis Alcock 1901

Key to the Indian species of Parapenaeopsis

1. Mastigobranchiae on 1st and 2nd pereopods. .. .. .. 2
- Mastigobranchiae absent on 1st and 2nd pereopods. .. .. 8

2. Second pereopods with basial spines. .. .. .. 3
- Second pereopods without basial spines. .. P. unata (Alcock)

3. Telson with pair of fixed subapical spines; at least distal ½ free portion of rostrum unarmed. P. stylifera (Milne Edwards)
- Telson without fixed subapical spines, with or without lateral movable spines; 1/3 or less free portion of rostrum unarmed. .. 4

4. Petasma with pair of long slender caliper-like distolateral projections directed forwards; thelycum with median tuft of long setae behind posterior edge of last thoracic sternite. ..

- Petasma with a pair of distolateral projections directed laterally or distolaterally, usually short and spout-like. .. .. 6

5 Third pereopods of female with basial spine; cardiac plate with 56-59 spinules. .. .. P. maxillipedo Alcock

- Third pereopods of female without basial spine; cardiac plate with 42-49 spinules. .. .. P. serrata (Kishinouye)

6. Postrostal carina reaching almost to posterior border of carapace; petasma with a pair of short, spout-like distolateral projections and pair of cap-like distal projections. .. .. 7

- Postrostal carina reaching 3/4 carapace; petasma with pair of distolateral projections directed laterally, cap-like distal projections absent. .. .. .. P. nana Alcock

7. Antennular flagella 0.5-0.6 length of carapace; thelycum with median tuft of setae on posterior plate. .. P. sculptilis (Heller)

- Antennular flagella 0.7 length carapace or longer; thelycum without a median tuft of setae on posterior plate. .. P. hardwickii (Miers)

8. Anterior plate of thelycum with V-shaped posterior edge, and 2 accessory ridges on anterior edge of posterior plate, rostrum with proximal 1/3 raising from carapace, remainder more or less horizontal. .. .. P. tenella (Bate)

- Anterior plate of thelycum with a more or less straight transverse posterior edge, no accessory ridges on anterior edge of posterior plate; rostrum inclined upwards at an angle to carapace for whole of its length. .. .. P. acclivirostris Alcock

The present collection comprises of eight species of this genus viz. P. nana, P. stylifera, P. maxillipedo, P. serrata, P. sculptilis, P. hardwickii, P. tenella and P. acclivirostris.

## Parapenaeopsis unata (Alcock, 1905)

(Pl.II, 18-21; IX, 5)

Parapenaeopsis unata Alcock, 1905:528; 1906:39; de Bruin, 1965:96-98.

Parapenaeopsis unata Menon, 1956:346; Mohamed, 1969:30; George, 1969:34; Thomas, 1971:195-196.

Parapenaeopsis probata Hall, 1961:96-98; 1962:27.

Material: Several specimens. Off Pudumadam, Gulf of Mannar (31-12-67) 8 males, carapace length, 18 - 22 mm; 34 females, 16 - 39 mm; (31-12-67) 3 males, 20 - 22 mm; 20 females, 23 - 39 mm; (30-12-68) 13 females, 21.7 - 37 mm; (1-2-69) 4 females, 23 - 36 mm; Kilakkarai (15-3-68) 1 male, 19 mm; 1 female, 24 mm. Collected from trawl catches. Depth of occurrence: 5 - 20 m.

Discussion: Parapenaeopsis unata Alcock collected from Gulf of Mannar agrees closely with the description given by Alcock (1906). The difference in the shape and length of the rostrum in males and females noticed by de Bruin (op.cit.) and Thomas (op.cit.) are clear in the present material. Although Hall (1961) created the new species P. probata based on certain minor differences de Bruin has synonymised it with P. unata as the shape of the rostrum, the proportions of the rostrum and antennular peduncle, the telson and the sixth abdominal segment, the nature of the anteroinferior angle of the carapace and the extend of development of the spine on the second pereopod are so identical in specimens from Singapore and Ceylon.

The colour of the fresh specimens collected during the studies agree with that has already been given (Thomas op.cit.). The largest specimen collected measured 39 mm in carapace length which is much larger than that recorded by Hall from Singapore and de Bruin from Ceylon.

Distribution: Southwest coast of India (George, 1969); Ceylon (de Bruin, 1965); Gulf of Mannar (Thomas, 1971); east coast of India (Alcock, 1906).

## Parapenaeopsis stylifera (Milne Edwards, 1837)

(Pl.IX, 6)

Penaeus styliferus H. Milne Edwards, 1837:418; Miers, 1879:304-305.

Penaeopsis styliferus, Bate, 1881:183.

Parapenaeopsis styliferus Nobili, 1903:4.

Parapenaeopsis stylifera Alcock, 1906:36-37.

Parapenaeopsis stylifera var. coromandelica Alcock, 1906:37; Menon, 1956: 346(Key); Kurian, 1953:761.

Parapenaeopsis stylifera de Man, 1911:9; Nataraj, 1942:468; Kurian, 1953: 761; Menon, 1956:346(Key); Ahmed, 1957:12; Dall, 1957:214(Key); Rao, 1967:1-17; 1969:127-140, figs. 16-22; Tirmizi, 1960:762, fig.6; 1968:193-203; George, 1969:34, 35; Jones, 1969:743.

Parapenaeopsis coromandelica Hall, 1962:27; de Bruin, 1965:99.

Parapenaeopsis stylifera coromandelica Racek and Dall, 1965:96-98.

Parapenaeopsis stylifera stylifera Racek and Dall, 1965:98.

Materials: Several specimens. Mangalore (19-1-68) 4 males, carapace length 17.2 - 18.8 mm; 5 females, 19.4 - 25mm; Cochin (18-12-69) 1 male, 23.1 mm; 1 female, 28 mm; Kilakkarai (21-12-67) 6 males, 14 - 16 mm; 8 females, 17-19.4 mm; (10-3-68) 2 females, 19.9, 18.4 mm; Mandapam (18-8-69) 2 males, 20, 20.5 mm; Durgavalasai, Palk Bay (10-3-68) 2 males, 12.3, 14.5 mm; 3 females, 15.6 - 22.5 mm; Adiramapattinam (28-9-68) 3 males, 14.5 - 16 mm; 3 females, 16.5 - 21.2 mm. Collected from shore seines, boat seines trawl nets. Depth of occurrence: 2 - 25 m.

Discussion: The differences in the telsonic armature of P. stylifera Milne Edwards and P. stylifera var. coromandelica of Alcock do not seem to be sufficient for assigning specific status to the variety coromandelica as done

Hall (1962). Racek and Dall (op.cit) were of opinion that the number and degree of development of the lateral spines of telson alone could not justify the specific separation of Alcock's variety from the original species of Milne Edwards, as all the morphological characters were in complete agreement in both species. Therefore, they considered the differences as infra-specific due to their geographical separation and proposed the two subspecies P.stylifera stylifera (Milne Edwards) and P. stylifera coromandelica (Alcock). Critical examination of the materials from the west and east coasts of India has clearly shown the great variability of some of these characters. Specimens from southwest coast of India and Palk Bay have 6 rostral teeth. But specimens from west coast possessed two pairs of well developed spines in addition to a pair of reduced spines on the distolateral aspect of telson. In specimens collected from east coast there was only one pair of well developed telsonic spines and another much reduced pair. In view of the above cited variation within the two 'varieties' and similarities between them, these two are evidently one and the same and hence may be synonymysed and treated as P. stylifera (Milne Edwards).

Distribution: West coast of India (Natarai, 1942; Kurian, 1953; Jones, 1969; Kasinath, 1969; 1968; George, 1969); east coast of India (Ahmed, 1957); Ceylon (de Bruin, 1965); Singapore (Hall, 1962; Nobili, 1903); Australia (Dall, 1957; Racek and Dall, 1965).

Penaeopsis serrillinoia Alcock 1906 (Pl.X, 1)

Penaeopsis serrillinoia Alcock, 1906:40-41; Hall, 1961:89-90; 1962:26; de Bruin, 1965:94-95.

Penaeopsis serrillinoia Natarai, 1942:468; Kubo, 1949:380-381; Menon, 1956:346 (Key) Dall, 1957:217.

Penaeopsis serrata Cheung, 1960:65 (Key); Cheng-Ming, 1965:15.

Penaeopsis serrata maxillipeda Racek and Dall, 1965:99; George, 1969:35.

Materials: Several specimens. Quilon (23-3-67) 7 males, carapace length, 16.5 - 17.2 mm; 12 females, 18 - 30 mm; Kilakkarai (20-9-67) 1 female, 14.9 mm; Off Pudumadam, Gulf of Mannar (30-11-68) 3 males, 15.5 - 19 mm; 17 females, 13.4 - 22.2 mm; Vedalai, Gulf of Mannar (14-6-67) 2 males, 12.1, 14.5 mm; 2 females, 16.5, 20.9 mm; (18-2-69) 1 female, 23.5 mm; Mandapam, Gulf of Mannar (10-8-70) 5 females, 16.4 - 25.5 mm; (10-11-70) 1 female, 17 mm. Collected from shore seines and trawl nets. Depth of occurrence: 2-10 m.

Discussion: Contrary to the suggestion of Hall (1961) that Alcock's P. maxillipeda may be considered as a geographical variety of P. serrata (Kishinouye) de Bruin (1965) has confirmed the specific identities of the two species, based on the comparison of the distinctive characters with those of the specimens collected from Ceylon waters. But Racek and Dall (1965) hold that these two are, so much similar in most of the diagnostic characters that only assignment of subspecies status could be justified. Detailed comparison of the materials collected during the present investigations, from Gulf of Mannar and Palk Bay has established beyond doubts the fact that P. maxillipeda and P. serrata are distinct species as pointed out by de Bruin (op.cit.). Although there is slight overlapping of the rostral formula, P. maxillipeda bears a tuft of setae behind the thelycal plate which is absent in P. serrata. The basial spines are present on the 3rd pair of pereopods, in P. maxillipeda; but absent in P. serrata. Cardiac plate has only 25 - 30 spinules which is much less than that of Kubo's specimens from Japan and Dall's specimens from Australia. Therefore the two are treated here as distinct species.

Distribution: West coast of India (Alcock, 1906; Nataraj, 1942; Kurian, 1953; George, 1969); Ceylon (de Bruin, 1965); East coast of India (Alcock, 1906); Singapore (Hall, 1961; 1962); Philippines (Racek and Dall 1965); East Indies (Racek and Dall, 1965); Japan (Kubo, 1949); Taiwan (Chong-Ming, 1965); Australia (Racek and Dall, 1965).

Parapenaeopsis cornuta (Kishinouye, 1900)

Penaeus cornutus Kishinouye, 1900:23.

Parapenaeopsis cornuta de Man, 1911:93.

Parapenaeopsis cornutus Kubo, 1949:374-378; Dall, 1957:215-217; Cheung, 1960:67 (Key).

Parapenaeopsis cornuta Racek, 1959:10; de Bruin, 1965:95-96; Muthu, 1972:147-148, fig.2.

Parapenaeopsis cornuta cornuta Racek and Dall, 1965:98-99.

Material: 14 specimens. Off Pudumadam, Gulf of Mannar (29-12-67) 1 male, carapace length 11.8 mm; 5 females, 10.8 - 15.4 mm; Vedalai, Gulf of Mannar (19-12-66) 1 male, 9 mm; 1 female, 11 mm; Thangachimadam, Palk Bay (14-11-67) 2 males, 10.2, 10.1 mm; 3 females, 13.7 - 14.9 mm; Andamans (10-8-67) 1 male, 17 mm. Collected from shore seines, boat seines and trawl nets. Depth of occurrence: 2 - 15 m.

Diagnosis: The specimens all smaller in size in comparision with P.maxillipedo as observed by de Bruin. The largest specimen collected measured only 17 mm in carapace length. The median tuft of setae is absent behind the thelycal plate. The 3rd pereopods do not bear basial spines as in P. maxillipedo. Considerable variation has been noticed in the rostral dentition from 6-9 dorsal teeth, although majority were having only 6 teeth.

*Parapenaeopsis acuminata* is caught in small numbers by trawlers, as well as boat seines and shore seines from Palk Bay and Gulf of Mannar. This is the first report of the species from Palk Bay and Gulf of Mannar.

**Distribution:** East coast of India (Mathai, 1972); Ceylon (de Bruin, 1965); East Indies (Racek and Dall, 1965, de Man, 1911); Australia (Dall, 1957; Racek and Dall, 1965); Hong Kong (Chacko, 1960); Japan (Kishinouye, 1900; Kubo, 1949).

*Parapenaeopsis sculptilis* (Heller, 1862)

(Pl.X, 2)

*Penaeus sculptilis* Heller, 1862:528; 1865:122; Miers, 1880:457.

*Parapenaeopsis sculptilis* Nobili, 1903:5; Balss, 1914:11; Boone, 1935: 80-84; Kubo, 1949:389-391; Menon, 1956:346 (Key); Ahmed, 1957; Dall, 1957:217-220; Rajyalakshmi, 1962:53, 55,56; Racek and Dall, 1965:100; Tirmizi, 1969:760-762; Kristensen and Walker, 1967:1-27, figs.5; Jones, 1969:743.

*Parapenaeopsis sculptilis* Burkenroad, 1934:59-60; Racek, 1959:10, 12, 14.

*Penaeopsis sculptilis* Alcock, 1906:37-38.

*Parapenaeopsis affinis* Hall, 1961:93-94; 1962:27.

**Material:** 4 specimens. Bombay (12-11-67) 2 males, carapace length 26.9, 29.5 mm; 2 females, 25.4, 36.9 mm. Collected from stake net and trawler catches. Depth of occurrence: 10-30 m.

**Discussion:** The specimens collected during the present studies agree well with earlier descriptions and hence do not afford further criteria for discussion. Unlike *P. hardwickii* the dorsomedian carinae of 1st and 2nd abdominal segments have shallow grooves. The carpocerite reaches the distal end of basal segment of antennular peduncle. The telson is unarmed.

The species although fairly common in Bombay, on the west coast and Kakinada and Waltair on the east coast, do not occur in the southern portion of the Indian Peninsula. The apparent sexual dimorphism of the rostrum is clear in the specimens examined. The rostrum of male is shorter than that of female and lacks unarmed portion.

Distribution: West coast of India (Alcock, 1906; Tirmizi, 1969; George, 1969); east coast of India (Alcock, 1906; Ahmed, 1957; Rajyalakshmi, 1962; George, 1969); Mergui (Alcock, 1906); Malaysia (Alcock, 1906; Racek and Dall, 1965); East Indies (Racek and Dall, 1965); Singapore (Hall, 1961); Hong Kong (Alcock, 1905) Australia (Dall, 1957; Racek, 1959; Kirkegaard and Walker, 1967; Racek and Dall, 1965).

## Parapenaeopsis hardwickii (Miers, 1878)

(Pl.X, 3)

Penaeus hardwickii Miers, 1878:300.

Parapenaeopsis sculptilis var. hardwickii Alcock, 1906:39.

Parapenaeopsis sculptilis var. cultrirostris Alcock, 1906:39.

Parapenaeopsis hardwickii Burkenroad, 1934b:60-64; Hall, 1961:93; 1962:26-27

Parapenaeopsis cultrirostris Kubo, 1949:378-380 (not figure 137).

Parapenaeopsis hardwickii Kubo, 1949:385-389 (not figure 140); Dall, 1957: 214(Key) ; Cheung, 1960:65 (Key); Kunju, 1960:82; Racek and Dall, 1965:101-102; Tirmizi, 1968: 137-140; Jones, 1969:743.

Material: 7 specimens. Bombay (12-11-67) 1 male, carapace length 16.4 mm; 6 females, 19 - 25.3 mm. Collected from the trawl and stake net catches. Depth of occurrence: 10-30 m.

Discussion: The descriptions given by Burkenroad (1934a), Kubo, (1949), Kunju (1960) and Racek and Dall (1965) agree fully with the specimens examined

from Bombay. The dorsomedian carina is absent on the 1st and 2nd abdominal somites. Telson bears 3 pairs of small lateral spines. The sexual dimorphism in the shape of the rostrum is exhibited by this species also as in P.sculptilis.

This species also is restricted to the norther region along the west and east coast of India like P. sculptilis.

Distribution: West coast of India (Kunju, 1960; Tirmizi, 1968; George, 1969); Indian Seas (Miers, 1878); east coast of India (Alcock, 1906); George, 1969); Singapore (Hall, 1961; 1962); East Indies (Racek and Dall, 1965); Hong Kong (Cheung, 1960); Japan (Kubo, 1949; Dall, 1957; Racek and Dall, 1965).

Parapenaeopsis tenella (Bate, 1888)

(Pl.II, 13-15)

Penaeus tenellus Bate, 1888:270-271; Kishinouye, 1900:22.

Penaeus armiger Ortmann, 1890:451.

Penaeus (Parapenaeopsis) tenellus de Man, 1907:455-456, 454.

Parapenaeopsis tenella de Man, 1911:9, 92; Balss, 1914:11; Yoshida, 1941: 15-16; Racek and Dall, 1965:108-109.

Parapenaeopsis tenellus Kubo, 1949:371-374; Liu, 1955:16-17; Dall, 1957: 221-223; Cheung, 1960:65.

Parapenaeopsis tenella Hall, 1961:89; 1962:26; de Bruin, 1965:98-99; George, 1969:36-37; Thomas, 1969:166-167; Mathu, 1972:147.

Material: Several specimens. Vedalai, Gulf of Mannar (15-2-67) 1 male, carapace length 6.5 mm; 1 female, 10 mm; Marakayarpattinam, Gulf of Mannar (19-2-68) 8 males, 6.8 - 7.1 mm; 15 females, 6.8 - 11.6 mm; Mandapam, Gulf of Mannar (22-3-69) 12 females, 9.6 - 12.7 mm; (10-11-70) 4 females, 8 - 11.5 mm; Thangachimadam, Palk Bay (5-8-67) 9 females, 8.4 - 9.6 mm (12-8-68) 2 females, 10.3 - 10.4 mm. Collected from trawlnet, shore seine and boat seine catches. Depth of occurrence: 2 - 15 m.

Discussion: The specimens collected from Palk Bay and Gulf of Mannar could be easily distinguished from the allied P. scolivirostris by the presence of the wing-like lateral expansions of petasma. The material on hand agrees with Dall's description in most of the details of structure, although, there are certain differences between the Indian specimens and those from Australia as noticed by de Bruin between the specimens collected by him, from Ceylon waters and the Australian forms. As pointed out by Thomas (1969) the Indian specimens agree with those from Australia in the length of rostrum, backward extension of the post rostral carina, length of the stylocerite and the length of the first pereopod while differing from specimens from east coast of Ceylon.

The species is commonly caught in the shore seines, boat seines and trawl nets; but less noticed due to the small size. This form the food item of many of the fishes, especially bottom feeders.

Distribution: Southeast coast of India (Thomas, 1968; Muthu, 1972); east coast of Ceylon (de Bruin, 1965); Singapore (Hall, 1961, 1962); China (Liu, 1955); Japan (Bate, 1888; Kishinouye, 1900; de Man, 1907; Kubo, 1949); Australia (Dall, 1957; Racek and Dall, 1965).

Parapenaeopsis scolivirostris (Alcock, 1905)

(Pl.II, 16,17; X, 4)

Parapenaeopsis scolivirostris Alcock, 1905:530; 1906:42-43.

Parapenaeopsis scolivirostris Barnard, 1947:382; 1950:604-605; Dall, 1957:215(Key); Kunju, 1960:83; Hall, 1966:99; George, 1969:37.

Materials: Several specimens. Quilon (22-3-67) 1 male, carapace length 7.4 mm; [illegible] females 9 - 14 mm; Cochin (20-3-67) 12 males, 5.6 - 6.6 mm; 51 females, [illegible] - 13.2 mm; Mandapam, Gulf of Mannar (22-3-69) 3 females, 10.5 - 11.2 mm;

(10-11-70) 7 females, 12 - 15.5 mm. Collected from trawl catches. Depth of occurrence: 8 - 20 m.

Discussion: This species which is very closely related to P. tenella differs from it in the absence of the characteristic lateral expansion of the petasma and the backward extension of the anterior thelycal plate. Although Knock and Dall (1965) suggested that the Palk Strait could be considered the zoogeographical boundary between the eastern species P. tenella and the western P. coniviroides, the presence of the latter species in the Palk Bay and Gulf of Mannar contradicts the above view.

The present material has been collected from the trawl catches alone showing that it prefers deeper waters unlike P. tenella which is caught in shore seines also.

Distribution: Persian Gulf (Alcock, 1906); west coast of India (Ranja, 1960; George, 1969); South Africa (Barnard, 1947; 1950; Hall, 1966); east coast of India (Alcock, 1906).

This is the first report of the species from Gulf of Mannar.

## Section Caridea

Four families of the section Caridea are dealt with in the present report.

### Key to the Indian families of Caridea

1. First pair of pereopods chelate or simple. . . . . 2
- First pair of pereopods subchelate. . . . . 16

2. Fingers of all 4 chelae slender, their cutting edges pectinate. . . . . Pasiphaeidae
- Cutting edges of fingers of chela not all pectinate. . . . . 3

3. Carpus of 2nd legs entire. First pair always with well developed chelae. . . . . 4
- Carpus of end legs usually subdivided into 2 or more joints; if not, first pair of legs not chelate. . . . . 10

4. 1st pair of legs with movable finger compressed, semicircular, deeply recessed in a slit in propodus when chela is closed. Rostrum dorsoventrally flattended. . . . . Pandalidae
- First pair of legs with normal chelae. Rostrum laterally compressed. . . . . 5

5. Rostrum immovable. Exopods on pereopods. . . . . Eucyphotocidae

- Rostrum movable. No exopods on pereopods. . . . . Rhynchocinetidae.

6. Pereopods usually with exopods, if not, fingers of chela with terminal brushes of long hairs. Mandible without palp. Fingers of chela usually with conspecuous terminal brushes, pereopods without exopods. Almost exclusively freshwater forms. . . Atyidae

Mandible with palp. Fingers of chela without terminal brushes of hairs. Pereopods with exopods. . . . . 7

- Pereopods without exopods. Chelae without terminal brushes of long hairs. . . . . 8

7. Last 3 pairs of legs not conspecuously lengthened; carpus of these legs distinctly shorter than propodus. . . . . Oplophoridae

- Last 3 pairs of legs enormously lengthened; carpus of these legs several times longer than propodus. . . . . Hymenocaridae.

8. Arthrobranchs and epipods at bases of 1st 4 pairs of pereopods. Upper antennular flagellum simple . . . . . Campylonotidae.

- Pereopods without arthrobranchs or epipods. Upper antennular flagellum bifid. . . . . 9

9. Mandible usually with incisor process; if not, 3rd maxilliped not expanded leaf-like. . . . . Palaemonidae.

- Mandible without incisor process. 3rd maxillipeds expanded, leaf-like . . . . . Gnathophyllidae.

10. Chela of 1st pair of pereopods distinct, at least on one side. . . . 11

- Only one pair of 1st pair of pereopods chelate, other end in claw-like dactylus . . . . . Processidae

12. Ends of fingers of 1st pair of chelae usually dark coloured. 1st pair of chelipeds short, rather heavy but not swollen. Eyes free, never very long. . . . . Hippolytidae

- Ends of fingers of 1st pair of chelae not dark coloured. Eyes either extremely long or partly or wholly covered by carapace . . . 13

13. Eyes extremely elongate, reaching almost to end of antennular peduncle; cornea small. 1st pair of legs shorter than and about as robust as second . . . . . Ogyrididae

- Eye usually partly or wholly covered by carpace, never very elongate. 1st pair of legs distinctly stronger than second, often unequal and swollen. . . . . Alpheidae

14. Carpus of 2nd legs not subdivided. Chelae of end pair of legs heavy, robust. . . . . Thalassocaridae

- Carpus of 2nd legs divided into 2 or more articles. Chelae of 2nd pair of legs small and slender. . . . . 15

15. Mandible bifid, with palp. Rostrum laterally compressed, distinctly dentate . . . . . Pandalidae

- Mandible simple without palp. Rostrum broad, inflated, prolongation of carapace with some dorsal denticles. . . . . Pasiphaeidae

16. Carpus of 2nd pair of legs multi-articulate. . . . . Glyphocrangonidae

- Carpus of 2nd pair of legs not subdivided. . . . . Crangonidae

Family Palaemonidae Randall 1839

Subfamily Palaemoninae Dana 1852

Only two genera viz. Palaemon and Macrobrachium are collected during the studies.

## Key to the genera of Palaemonidae

1. Supraorbital spine present. . . . . Pontonia
- Supraorbital spine absent. . . . . 2

2. Branchiostegal spine present. . . . . 3
- Branchiostegal spine absent. . . . . 7

3. Mandible without palp. . . . . 4
- Mandible with palp. . . . . 5

4. First pleopod of male with a well developed appendix interna on the endopod. Branchiostegal groove absent. Propodus of fifth leg without transverse setae on the distal part of the posterior margin . . . . . Leandrites
- First pleopod of male without an appendix interna on the endopod. Branchiostegal groove visible as a sharp line. Propodus of fifth leg with transverse rows of setae on the distal part of the posterior margin. . . . . Palaemonetes

5. Eyes without pigment, cornea reduced. Anterior margin of basal segment of antennular peduncle concave, gradually merging into a strong anterolateral spine. No branchiostegal groove on the carapace. Propodus of fifth pereiopod with transverse rows of hairs in the distal part of posterior margin. Mandibular palp two-jointed. . . . . Orconectes
- Eyes distinctly pigmented, cornea well developed. Anterior margin of the basal segment of antennular peduncle rounded, anterolateral spine small. . . . . 6

6. First pleopod of male with a well developed appendix interna on the endopod. Branchiostegal groove absent. Propodus of fifth pereiopod without transverse rows of setae on distal part of posterior margin. The two median setae of posterior margin of telson very strong. Mandibular palp two jointed. . . . . Leander

First pleopod of male without or with a rudimental appendix interna on endopod. Branchiostegal groove generally present, visible as a sharp line. Propodus of fifth pereiopod with transverse rows of setae on distal part of posterior margin. Two median hairs of posterior margin of telson slender. . . . . Palaemon

Hepatic spine absent. . . . . 8

Hepatic spine present. . . . . 10

Mandible without palp. Eyes without pigment. . . . . Troglocaridina

Mandible with palp. Eyes pigmented. . . . . 9

Second legs slender, smooth; carpus 1.5 times or more as long as chela. Rostrum elongate, reaching beyond the scaphocerite. . . . Leptocarpus.

Second legs robust, spinulate; carpus less than half as long as chela. Rostrum very short and high not reaching end of scaphocerite.. Caridina

Mandibular palp absent. Dactylus of last three legs simple. Pseudopalaemon

Mandelbular palp present. . . . . 11

Dactylus of last three legs simple . . . . . Macrobrachium

Dactylus of last three legs biunguiculate. . . . . Brachycarpus

## Genus Palaemon Weber 1795

Holthuis (1952) devided the genus into 4 subgenera viz. Hemipalaemon, Exopalaemon, Palaemonides and Palaemon mainly based on the presence or absence of the crest of the rostral base, length of the dactyli of last three legs and the number of joints of the mandibular palp. Two species, one each, representing the subgenera Hemipalaemon and Exopalaemon are present in the collections under study.

### Key to the Indian species of Palaemon

1. Dactylus of last three pereopods very long and slender; last two pairs of pereopods excessively long and flagelliform, with dactylus much longer than carapace; carpus of second pereopods much more than $\frac{1}{2}$ length of palm. Basal crest of rostrum with atmost 7 teeth; fingers of second legs more than twice as long as carpus. . . . . P. (Hemipalaemon) tenuipes

Dactylus of last three pereopods not abnormally long; 3rd and 5th legs with dactyli scarcely $\frac{1}{2}$ and atmost 1/3 length of propodus respectively. Pleopods normal; one or more subapical dorsal teeth or rostrum. Last four abdominal somites bluntly carinate dorsally. . . . P. (Exopalaemon) styliferus

### Palaemon (Hemipalaemon) tenuipes (Henderson, 1893)

(Pl.XI, 1)

Leander tenuipes Henderson, 1893:440; Nobili, 1905b:7; Kemp, 1917:206; 1917a: 234; 1925:289; Chopra, 1943:5; Rajyalakshmi, 1962: 53, 58, 59.

Palaemon (Hemipalaemon) lanceus Holthuis 1950:44-45; Ganapati and Subrahmanyam, 1966:13; Kunju, 1967:1385; George, 1969a:37-38; 1969a:171-74.

Materials: 19 specimens. Bombay (13-11-67) 8 males, carapace length, 10 - 11.3 mm; 4 females (2 berried) 10.9 - 13 mm; Mangalore (15-12-67) 3 females 9.6 - 10.2 mm; Calicut (15-4-66) 2 females, 12.8, 13.2 mm; Vedalai, Gulf of Mannar (18-11-66) 1 male, 11.4 mm; Nagapattinam (2-3-67) 1 male, 10 mm. Collected from stake net, shore seine, boat seine and trawl net catches. Depth of occurrence 2 - 15 m.

Discussion: The specimens agree well with the descriptions of earlier workers. The rostrum varies much in length, with a basal elevated crest bearing 5 - 7 dorsal teeth on it and 2 - 6 ventral teeth along the length of the rostrum. Antennal and branchiostegal spines equally developed, the later being placed on the frontal margin of carapace, unlike its congeners. Antennal scale narrower towards the anterior end, and about $3\frac{1}{3}$ as long as its greatest breadth. Palm of second pereopods are characteristically swollen, with straight fingers having curved tips. Last three legs are very long due to the lengthening of the distal most two segments. 4th and 5th legs exceed the length of the entire shrimp. Pleopods are exceptionally long.

This species of Palaemon occur throughout the Indian coast line. But it forms a major fishery only in Bombay while in Gujarat it forms only a fishery of lesser importance. In the estuaries and foreshore areas of West Bengal this species forms a fishery of much less magnitude.

Distribution: West Coast of India (Henderson 1893); East coast of India (Henderson 1893; Nobili, 1905b; Kemp, 1917; Holthuis, 1950); Burma coast (Henderson, 1893; Kemp, 1917); Philippines (Manso, 1939); New Zealand (Kemp, 1917).

This is the first report of the species from the Gulf of Mannar.

Genus Macrobrachium Bate 1868

Key to Indian species of Macrobrachium

1. Carpus of 2nd pereopods distinctly longer than merus. . . . . 2
   Carpus of 2nd pereopods about as long as or shorter than the merus. . . . . 12

2. Rostrum with a distinct elevated basal crest generally very long or with a distinct naked portion in the distal half of upper margin.. 3
   Rostrum without a distinct elevated basal crest. . . . . 6

3. Lower margin of rostrum with 8 - 14 teeth. Rostrum long and curved upwards. Tip of telson reaching beyond tip of longer posterior spines. . . . . 4
   Lower margin of rostrum with 4 - 7 teeth. Rostrum generally straight distal part of rostrum without teeth, tip of telson overreached by the longer posterior spines. . . . . 5

4. Carpus of 2nd pereopods in adult male slightly longer than or as long as chela; fingers of that leg of same length as palm . . . . . M. rosenbergii (de Man)
   Carpus of 2nd pereopod in adult male as long as slightly longer or slightly shorter than chela; fingers of that leg a little less than half as long as palm. . . . . M. villosimanus Tiwari

Rostral crest not much elevated provided with 5-9 teeth; palm of 2nd leg not swollen; fingers shorter than palm. . . M.lamarrei (H.Milne Edwards)

Rostral crest distinctly elevated, provided with 5-9 teeth; young specimens with swollen palm of 2nd leg and fingers longer than palm. Carpus of 2nd leg in adult male, shorter than chela. . . . . M. malcolmsonii (H.Milne Edwards)

Fingers of large chela of adult male with numerous teeth on cutting edges. . . . . 7

Fingers of large chela adult male almost with 1 or 2 teeth in proximal part of cutting edges. . . . . 8

2 or 3 teeth of upper margin of rostrum behind orbit. 2nd chelae of adult male more or less cylindrical.
Fingers with more than 10 denticles on the cutting edges and distinctly shorter than palm. . . . . M. australis (Guerin - M.)

4-6 dorsal teeth of rostrum behind orbit. . . M. acanthus (Nobili)
2 or 3 dorsal teeth on rostrum behind orbit 2nd leg of adult male with many distinct tubercles; fingers of this leg with 1 or 2 distinct proximal teeth on cutting edges. . . . . 9

Carpus of 2nd leg of adult male longer than chela. . . . . 10
Carpus of 2nd leg in adult male shorter than chela. . . . . 11

Chela of 2nd leg without tubercles on each side of cutting edges. Rostrum with 9-11 dorsal teeth, 3 of which generally placed behind orbit. . . . . M. idae (Heller)
Rostrum with 12-15 dorsal teeth; 2 of which generally placed behind orbit. . . . . M. idella (Hilgendorf)

11. Large chela of adult male with tubercles at both sides of cutting edge of dactylus. Fingers of large chela of adult male at least in their basal half, provided with numerous long hairs, forming a velvety coat. All joints of 2nd legs of adult male pubescent. . . . . .M. rude (Heller)

- Large chela of adult male without tubercle at both sides of cutting edges of dactylus. Chelae of 2nd legs in adult males with fingers covered with stiff or velvety hairs on the entire surface or in proximal part only. Lower margin of rostrum with 5 - 7 teeth. Rostrum curved upwards. . . . . M. equidens (Dana)

12. 5th leg conspicuously longer than 4th. Rostrum short and high with many dorsal teeth. 2nd legs of adult male smooth. . M. nimbila (Kemp)

- Fifth legs of about same length as the 4th. . . . . 13

13. Fingers of 2nd legs of adult male with 1 or 2 fairly large teeth. Smaller teeth may be present between the first tooth and the base of fingers; anterior tooth of dactylus placed in or slightly before the middle of finger. . . . . M. javanicum (Heller)

- Fingers of 2nd legs of adult male with more than 4 teeth placed at regular intervals, sometimes restricted to proximal part. Teeth generally of equal size, one proximal may be larger. Fingers with velvety pubescence at the bases. Dorsal rostral teeth start at the distal third of carapace. . . . . M. scabriculum Heller

Macrobrachium rosenbergii (de Man)
(Pl. XI, 2)

Palaemon rosenbergii de Man, 1879:167.

Palaemon carcinus 1790:402; de Man, 1879:165; Rai, 1933:806; Panikkar, 1937: 346; Patwardhan, 1939:222; 1945:71; Natarajan, 1942:468; Tiwari, 1955:231-32; Ahmed, 1957; John, 1957:95-102; Rajyalakshmi, 1961:181-84; 1962:53.

Macrobrachium rosenbergii Holthuis 1950:111-19 (complete synonymy) Ling, 1961:55-60; 1962:1-11; Raman 1964:21-23; 1967:649-69; Bhimachar, 1965:1, 4, 6; Rao, 1965:19-25; 1967:252-79; Ganapathi and Subrahmanyan, 1966:13; Kunju, 1967:1305; 1967:1536-37; 1967:9-11; George, 1969a:38-39; 1969b: 179-204.

Material: 7 specimens. Ernakulam (12-2-66) 2 males, carapace length, 17, 18 mm; Kadathuruthy (1-4-67) 2 males, 30, 33 mm; 2 females, 24.5, 24.5 mm; Pullamadom Creek, Palk Bay (2-9-66) 1 female, 36 mm. Collected from estuaries, streams and paddy fields. Depth of occurrence 1 - 3 m.

Diagnosis: Sexual dimorphism pronounced, adult male differing from the adult female in many respects. Rostrum in female more strongly upturned at distal portion being less deep than in adult male. Rostral formulla range $\frac{12-14}{12-14}$ majority being in the range of $\frac{12-13}{12-13}$, with greater interval between the teeth near the tip. The large cheliped much longer and stouter in males than in females. Joints beset with broad-based spines. Finger tips strongly incurved. Mobile finger of male stouter than immobile finger and densely pubescent. Telson with acute tip, inner terminal spinule longer than the outer one, falling short of the tip of telson.

Being the largest freshwater species M. rosenbergii is economically very important, contributing largely to the freezing industry during the

season. The species is much in use in the cultural practices abroad and in certain places in India.

Distribution: Indian Ocean (Olivier 1811; Lamarck, 1818; Desmarest, 1823; 1825; Voigt, 1836; H.Milne Edwards, 1837, 1838); Northwest Indian (Sharp, 1893; Henderson, 1893; Doflein, 1900; Rai, 1953); Southwest India (Henderson and Matthai, 1910, Panikkar, 1937; Menon, 1938; Nataraj, 1942); Ceylon (Tennent, 1861; Doflein, 1900); Southeast India (H.Milne Edwards, 1837; Von Martens, 1868; Henderson, 1893; Sharp, 1893; Doflein, 1900; Henderson and Matthai, 1910); Burma (Henderson, 1893); Mergui Archipelago, (de Man, 1888a; Henderson, 1893); Malay Peninsula (Von Martens 1868, 1876; Walker, 1887; de Man, 1897; Lanchester 1901; Kemp, 1918a: Boone, 1935); Thailand (Suvatti, 1937; Von Martens, 1868, Pearse, 1953); Viet Nam (Ortmann, 1891; Thompson, 1901; Serene, 1937); Philippines (Canto de Klein 1895; Estampador, 1937) Japan (Von Martens, 1868); East Indies (de Man 1879; 1892; 1898a; 1902; 1908; Von Martens, 1868; Miers, 1880; Thallwitz, 1892; Nobili, 1899, 1900; Schenkel, 1902; Roux, 1921, 1923; 1927); Australia (Roux, 1933a; Gordon, 1935).

Macrobrachium australe (Guerin-Meneville, 1838)

(Pl.XI, 5)

Palaemon australis Guerin-Meneville, 1838:37.

Palaemon sundaicus Heller 1862:414, pl.2, figs.38, 39; 1865:115; Ortmann, 1891:719.

Palaemon dayanus Heller, 1865:120, pl.11, fig.3; Haswell, 1882:197; Coutiere, 1901:325, pl.13, figs.38, 39.

Palaemon dienas von Martens 1868:41; Miers 1877:493; 1880:383; de Man, 1888: 556; Ortmann, 1891:718; 1894:10; Thallwitz 1892:15;

Henderson 1893:442; Coutiere 1901:388, pl.14, figs. 41-43; Schenkel, 1902:508; Adamson 1935:17; 1939:36.

Palaemon serratus Hoffmann, 1874:35, pl.7, fig.59; Ortmann, 1891:720.

Palaemon (Hymalaemon) dispar de Man, 1892:427, pl.26, fig.34; 1893:304; 1902:766; 1915:435, pl.29, fig.14; Coutiere, 1900: 1266; Nobili, 1902a:7; 1907:361; Borradaile, 1907:67; [illegible], 1910:567; Roux, 1917:595; 1919:536; 1923:7; 1928a:219; 1930:556; 1933:6; 1934:551; 1954a:227.

Macrobrachium australe Holthius 1949:291; 1950:124-35.

Material: 2 specimens. Muthupet, Palk Bay (27-9-68) 2 males, carapace length, 22.2, 26.2 mm. Collected from the Muthupet Swamp area. Depth of occurrence 1 - 2 m.

Discussion: The specimens collected during the present studies agree with description given by Holthuis (1950) except for minor differences. The rostrum is almost straight, although it looks as if turning a little upwards extending beyond the antennular peduncle and falling short of the tip of antennal squame. There are 11 dorsal teeth and 5 ventral teeth, two being placed behind the level of the posterbital margin Hepatic spine situated a little ventral to the level of the antennal spine. 4th and 5th somites with pleura having rounded posterior margins.

Large second pereopods with carpus longer than merus but shorter than chela, fixed finger with 2 larger spines of unequal size near the base and 10 dentieles along the cutting edge, the movable finger bearing 2 large spines of more or less equal size and 14 dentieles along the cutting edges. The [illegible], carpus, palm and finger covered with velvetty hairs. Besides, thick

coarser hairs present on either side of the cutting edges on the fingers. Ischium with spinules and isolated long hairs only. Pleopods typical in shape. Telson elongate with paired dorsal movable teeth and terminal teeth. Uropods longer than telson, exopod with convex outer margin coming distally in a spine, with an additional spine on its inner aspect.

Distribution: Seychelles (Borradaile, 1907) Madagascar (Hoffmann, 1874; Coutiere, 1900; 1901; Lenz, 1910) Mauritius (Richters, 1880; Ward, 1942) Reunion (Roux, 1934); East Indies (Nobili, 1899; 1900; Heller, 1862; 1865; de Man, 1888, 1892, 1895, 1893, 1902; Roux, 1917, 1919, 1925; 1928a; 1953, 1950; Von Martens, 1860; Thallwitz, 1892; Schenkel, 1902; Ortmann, 1894; Australia (Heller, 1865); Pacific Islands,(Guerin, 1838; Miers, 1880; Ortmann, 1891; Nobili, 1907; Adamson, 1935, 1939).

Macrobrachium annulum (Nobili, 1906)

(Pl.X, 4)

Palaemon (Pseudopalaemon) annulus Nobili, 1906a:258; 1907:362, pl.1, fig.5; Roux, 1926:221, figs.47-51 (Non Palaemon (Pseudopalaemon) annulus Boone, 1935:157, pl.40).

Palaemon nobili Henderson and Matthai 1910:295, pl.17, fig.6.

Macrobrachium annulus Holthuis 1950:135-36.

Material: 1 specimen. Pullamadam, Palk Bay (8-11-67), 1 male, carapace length, 33.8 mm (Total length, 80 mm). Collected from the fresh water pools. Depth of occurrence 1 - 2 m.

Remarks: The specimens agree well with the description of Henderson and Matthai (1910). The rostrum is short, extending a little less than the tip

of the antennular peduncle, it s tip tapering rather abruptly and slightly turned upwards. Out of the 12 dorsal teeth 4 are behind the level of the posterbital margin. The intervals between distalmost, penultimate and antepenultimate teeth are more than those between the ones proximal to them. There are 2 ventral teeth. Stylocerite reaches almost to tip of second antennular segment, exopbocerite being longer than antennular peduncle and with outer margin slightly convex at the proximal portion and straight near the tip.

Large second cheliped are subcylindrical and unequal. Unlike the males described by Henderson and Matthai (op.cit.) the right chela of the present material is longer than left. The carpi and palms in both chelipeds are slightly compressed and covered with small granules. The cutting edges of fingers with rows of tubercles on either side with alternating tufts of long hairs, 10 tubercles on the fixed finger and 8 on the movable finger on each side. There are two large teeth near the proximal end of the cutting edge of movable finger. There are 2 large teeth and 4 smaller ones on the fixed finger. The carpus of left cheliped is much longer than the manus and the fingers are less than half the length of the palm as was noticed by Henderson and Matthai (op.cit) in their material. The measurements in millimetres of the joints of the two chelae are as follows:

| | Total length | Ischium | Merus | Carpus | Palm | Finger |
|---|---|---|---|---|---|---|
| Right cheliped | 85.5 | 11.2 | 17.0 | 25.0 | 22.2 | 10.1 |
| Left cheliped | 73.2 | 11.2 | 14.0 | 20.0 | 18.5 | 9.5 |

The apex of telson is less acute than in M. rosenbergii and malcolmsonii, the inner lateral spinules extending beyond the tip, the outer

being much shorter. The setae in between the inner lateral spinules are longer and numerous.

Distribution: Southeastern India (Henderson & Matthai, 1910); New Caledonia (Roux, 1986); Tuamotu Islands (Nobili, 1906a, 1907).

M. annulus is reported from the present locality for the first time.

Macrobrachium idella (Hilgendorf, 1898)

(Pl. XI, 5)

Palaemon nasutus, Pfeffer, 1889:34 (non Hilgendorf, 1879)

Palaemon (Eupalaemon) idae idella Hilgendorf, 1898:29, fig.A.

Palaemon (Eupalaemon) multidens Coutiere 1900:1266; 1900a:25; Nobili, 1905:9.

Palaemon multidens Coutiere, 1901:327, pl.14, fig.40.

Palaemon idae Henderson and Matthai 1910:285, pl.15, fig.3, pl.16, fig.3.

Macrobrachium idella Holthuis 1950:146-47.

Material: 15 specimens (all from Kerala). Payyoli River (21-6-65) 4 males, carapace length, 14.6 - 19.8 mm; Calicut (14-10-64) 4 berried females, 17 - 19.9 mm; Udayamperoor (2-4-67) 5 males, 9.5 - 24.2; 3 females 11.7 - 13.9 mm; Vaikom (3-4-67) 2 males, 8.9, 13 mm; 2 females, 8.5, 11.6 mm. Collected from estuaries, streams and paddy fields. Depth of occurrence 1 - 3 m.

Discussion: Although M. idella resembles M. idae closely the distinguishing characters cited by Holthuis (1950) are quite distinct in the specimens on hand. The rostral dentition was $\frac{12-4}{4}$ in most of the specimens except in one specimen which had only 11 dorsal teeth. There were invariably 2 dorsal teeth behind the level of posterior orbital margin. Besides, the carpus in

all the specimens examined was shorter in comparison with the chela except in three specimens. The rostrum with equidistantly placed teeth on the dorsal elevated, convex portion, those near the tip being separated by a wider gap. Antennal scale extending as far as tip of rostrum, the lateral terminal tooth falling considerably short of the anterior margin of the squame. Telson with proximal pair of movable dorsal spines at the middle and distal pair at midway between proximal pair and apex. Outer terminal spines of telson much shorter than apex, inner being double the length of the apical process.

Distribution: East Africa (Pfeffer, 1889; Hilgendorf, 1898); Madagascar (Coutiere, 1900; 1901); Southwestern India (Henderson, and Matthai, 1910); Southeastern India (Nobili, 1903b).

## Macrobrachium equidens (Dana 1852)

(Pl. XI, 6)

Palaemon equidens Dana 1852:26; 1862a:591; 1955:12, pl.39, fig.2; Weiten Weber 1854:62; de Man, 1888a:Ortmann, 1891:718 (Non Lanchester, 1901:565, pl.34, fig.4; Non Palaemon equidens Heller 1862:48).

Palaemon (Eupalaemon) sundaicus de Man, 1897:779; 1898:708, pl.37, figs.70 m, n, 71; Weber, 1897:165:Hilgendorf; 1898:30; Coutiere, 1900:1266; Lanchester, 1901:568; Nobili, 1903:8; Roux, 1917:597; 1919:334; 1921:590; 1923:6; 1932:569.

Palaemon sundaicus Coutiere, 1901:332, pl.14, figs.44-46; Lanchester, 1906: 132; Coulen 1914:3; Stebbing 1915:73; Kemp, 1918a:261; Yu, 1931:276; Estampador, 1937:489; Barnard, 1947:390.

Palaemon (Exopalaemon) annandalei Kemp, 1899:242; de Man, 1908a:369; 1915: 487, pl.29, figs.10,11; Roux, 1917:597; 1919:334; 1934a:218.

Palaemon sulcatus Henderson and Matthai 1910:289-291, pl.16, fig.4 a - g; Panikkar, 1937:346; Katona, 1942:468.

Macrobrachium sundaicum Suvatti, 1937:49.

Macrobrachium equidens Tiaki and Tsuchiya 1923:62, pl.6, fig.1; Holthuis, 1950:162-72 (full synonymy); George 1969a:8, 41.

Material: 6 specimens. Korapuzha estuary (10-5-66) 1 male carapace length, 11.9 mm; (7-7-66) 2 males, 12.2, 21.8 mm; Muthupet Swamp (27-9-68) 3 berried females, 32 - 34.2 mm. Collected from Stake net catches. Depth of occurrence 2-4 m.

Discussion: The specimens on hand agree well with earlier descriptions. The rostrum with a well defined curve with upturned tip. Dorsal rostral teeth 10-12 of which 3 are placed posterior to the level of posterbital margin and 4 - 5 ventral teeth. Hepatic and antennal spines in the same longitudinal axis, the hepatic lying close behind and below the antennal spine which has a strong carina extending posteriorly almost to the hepatic spine. The 4th and 5th abdominal segments are provided with pleura having rather acute posteroventral margins. Telson has the usual armature, consisting of two pairs of dorsal movable spines. The distal end bears the small outer pair of spines which are less than 1/3 the length of inner pair which extends beyond the apical process of telson.

Second legs of males are large with carpus longer than merus and a little shorter than chela. Fingers are densely covered with setae. Cutting

edges have 1 or 2 large spines near the proximal end. The 5th and 4th pereopods are of equal size.

Distribution: East Africa (Hilgendorf, 1898; Coutiere, 1901; Stebbing, 1915; Rathbun, 1935); South Africa (M. Weber, 1897; Stebbing, 1915, 1925; Barnard, 1926); Madagascar (Coutiere, 1900, 1901); Southwestern India (Henderson and Matthai, 1910; Matthai, 1942; George, 1969a); South eastern India (Nobili, 1903b) Mergui Archipelago (de Man, 1888a); Malay Peninsula (Dana, 1852; Nobili, 1903a; Kemp, 1918a; Sewetti, 1937); Thailand (Sewetti, 1937); Viet Nam (Rouvel, 1932); China (Yu, 1931); Philippines (Coulon, 1915 ; Estampador, 1937); Japan, (Kubo, 1941); Formosa (Kubo, 1940); East Indies (de Man, 1892; 1897; 1902; 1915; Nobili, 1899; Rathbun, 1910; Roux, 1917; 1919; 1921; 1925; 1932; 1934a).

Subfamily Pontoniinae Kingsley 1878

This subfamily is represented by three genera.

Key to the genera of Pontoniinae

1. Mandibular palp present, usually composed of two segments; rostrum laterally compressed with conspicuous teeth; dactyles of last three legs simple. . . . . 2
- Mandibular palp absent. . . . . 3

2. Second maxilliped with podobranch; first pleoped of male with appendix interna (free-living). . . . . Ureocaridella.
- Second maxilliped without podobranch; first pleoped without appendix interna (free-lving or associated with crinoids). . . . . Palaemonella.

3. Antennal scale well developed. . . . . 4
- Antennal scale rudimentary. . . . . 15

4. Dactylus of last three legs simple or biunguiculate, but without basal protuberance. . . . . 5

\- Dactylus of last three legs simple or biunguiculate and with a large basal protuberance. . . . . 13

5. All three maxillipeds with exopods. . . . . 6

\- Exopods absent from some or all maxillipeds. . . . . 12

6. Inner lacinia of maxillula narrow; free-living or epizootic on coelenterates or echinoderms. . . . . 7

\- Inner lacinia of maxillula very broad; endozootic in lamellibranchs or ascidians. . . . . .

7. Carpus of first leg not segmented. . . . . 8

\- Carpus of first leg segmented (rostrum laterally compressed, with teeth; carapace not areolated) . . . . . Thoracotozoria.

8. Carapace not areolated; basal antennular segment normal in form; abdominal pleura usually rounded inferiorly. . . . . 9

\- Carapace areolated; basal antennular segment greatly attenuated anteriorly; third to fifth abdominal pleura sharply pointed inferiorly (rostrum laterally compressed, with dorsal teeth; associated with alcyonaria). . . . . Penneuria.

9. Rostrum laterally compressed, with conspicuous teeth. . . . . 10

\- Rostrum depressed and toothless (associated with crinoids). . Pontoniopsis.

10. Carapace not depressed (free-living or associated with coelenterates or echinoderms). . . . . Periclimenes.

Carapace depressed, often very strongly (associated with corals). . . . Hamiltina

11. Rostrum laterally compressed in distal half, toothless or with teeth at apex only; dorsal spines of telson very small. . . . Anchialina

- Rostrum depressed, toothless; dorsal spines of telson usually large. . . . . Pontonia

12. Rostrum toothless; carapace not sculptured, without supra-orbital crest; no teeth on first abdominal somite; free-living or associated with gorgonians. . . . . Pontoniidae.

- Rostrum with teeth; carapace deeply sculptured with supra-orbital crest on either side armed with teeth; a mid-dorsal tooth on first abdominal somite; associated with red coral. . . . . Hamodactylus.

13. Rostrum very long; carapace areolated, with huge antennal and supraorbital spines and with pterygostomian spine; abdominal pleura sharply pointed inferiorly. . . . . Contiocaris.

- Rostrum little if at all longer than scale; carapace not areolated, without supraorbital or pterygostomian spines; antennal spine when present short; abdominal pleura inferiorly rounded. . . . . 14

14. Dactylus of last three legs with basal protuberance double (rostrum toothless, concave above associated with echmoids). . . . Stenocionops.

- Dactylus of last three legs with basal protuberance single. . . . . 15

15. Rostrum laterally compressed, frequently with teeth; inner lacinia of maxillula narrow; dactylus of last three legs with single claw and a hoof-shaped basal protuberance; living on corals. . Gnathophausia

- Rostrum depressed, toothless; inner lacinia of maxillula very broad; dactylus of last three legs with two claws and flat basal protuberance; living in lamellibranchs. . . . . Gnathophyllum.

16. Rostrum present, with or without teeth distal lacinia of maxilla well developed; all maxillipods with exopods; dactylus of last three legs biunguiculate (associated with sponges). . . . . Penaeus

- Rostrum absent; distal lacinia of maxilla rudimentary; second and third maxillipods without exopods; dactylus of last three legs simple. . . . . Parapenaeopsis.

Genus Parapenaeopsis Coste 1844

Parapenaeopsis (Harpiliopsis) brevicarinata (Schenkel, 1902)

(Pl.IV, 4-8)

Bithynis sp. Coutiere, 1898:198.

Amphicaris brevicarinata Schenkel, 1902:563, pl.15, figs.21a - m; Burkenroad, 1917:355.

Palaemonella aberrans Nobili, 1904:233

Harpiliopsis latirostris Lenz, 1905:380, pl.47, figs.14, 14a - c.

Amphicaris aberrans Nobili, 1906a:52, pl.4, figs.9, 9a, b; 1906b:64; Kemp, 1916:389; Burkenroad, 1917:356.

Parapenaeopsis hardwickiana Rathbun, 1914:655, pl.1, figs.1-3.

Amphicaris hardwickiana Burkenroad, 1917:356.

Parapenaeopsis (Amphicaris) brevicarinata, Kemp, 1922:185-91; Barnard, 1947:391; 1950:749, figs.150 e-h; Mayer, 1947: 168-76, figs.1-10.

Parapenaeopsis (Harpiliopsis) brevicarinata Balthis, 1952:69-73 (Full synonymy)

Parapenaeopsis brevicarinata Gravely, 1927:137, pl.19, fig.3.

Material: 4 specimens. [redacted] Kemp, Gulf of Mannar (28-8-67), 1 berried female, carapace length, 9.4 mm; Thonithurai, Gulf of Mannar (7-8-67) a

1 berried female, 8.5 mm; (21-8-67) 1 berried female 8.6 mm; Rameswaram (28-8-68) 1 berried female, 9.9 mm. Collected from the giant sea anemone, Stoichactis sp. Depth of occurrence: 1-2 m.

Discussion: The specimens collected during the present studies agree well with the detailed description of Kemp, (1922) and therefore does not afford any further criteria for discussion. The colour also confirms to that given by Kemp (op.cit.) probably because the specimens collected by Kemp were also from more or less same locality in Gulf of Mannar.

Live specimens were observed to move about freely on the upper surface as well as below the disc of the sea anemone. They were left out in most of the cases when the anemone retreated below the surface of the sea bottom and could be easily collected by a scoop net. Specimens maintained in the aquarium were often seen exhibiting a rhythmic movement by their large chelipeds as well as the uropods. They survived for several months till the water supply was affected by a bloom of Trichodesmium sp.

Most of the female specimens observed were berried with large egg masses of light yellow colour. Males were also found to occur with these females, in the same anemone.

Distribution: Red Sea (Coutiere, 1898; Nobili, 1904, 1906b); Arabian coast (Nobili, 1905, 1906); Persian Gulf (Nobili, 1906); Western Indian Ocean (Richeters, 1880; Barnard, 1947); Gulf of Mannar (Kemp, 1922; Gravely, 1927; Meyer, 1947); Andaman Islands (Kemp, 1922); China (Yu, 1936); Japan (Kubo, 1940); East Indies (Zehntner, 1894; Schenkel, 1902; de Man, 1902); Australia (Haviland-Kent, 1893; Rathbun, 1914; Borradaile, 1917; Mc Culloch and Mc. Neill, 1925; Stephenson et.al, 1951); Pacific Ocean (Kemp, 1922).

## Genus *Gonobdrium* Peters 1852

### Key to Indian species of *Gonobdrium*

1. Basal process of dactylus of last three legs with a small tooth on proximal side; posterior of the two pairs of spines on back of telson situated about mid way between first pair and apex. . . . 2

\- Basal process of dactylus of last three legs without tooth; posterior of the two pairs of spines on back of telson situated much nearer to the apex than to first pair. . . . . *G. javidanum*

2. Antepenultimate segment of 3rd maxilliped less than twice as long as broad; fixed finger of 2nd leg with foremost tooth very broad and low, occupying greater part of distal half, lateral spines of telson tip situated at apex. . . . . *G. hirsutimanicatum*

Antepenultimate segment of 3rd maxilliped rather more than twice as long as broad, fixed finger of 2nd leg with foremost tooth small and triangular; lateral spines of telson tip, shifted forward on to dorsal surface, not nearly reaching apex. . . . . *G. pinnaeensis*

### *Gonobdrium javidanum* Peters, 1852

(Pl.IV, 9-12)

*Gonobdrium javidanum* Peters, 1852:594; 1852a:288; Ramm, 1852:84; 1852a:571; 1855:12; pl.37, fig.1; Nobili, 1906b:66; Barnedaile, 1917a:324, 395; Kemp 1922:283, fig.105; Chopra 1931:306; Kubo, 1940: 62, figs.26, 27; Barnard, 1950:801; Holthuis, 1952:195-99(Complete synonymy)

Gonodactyus melanurus Peters, 1852:594; 1852a:289; Bate, 1888:707, pl.124, figs.1, 2; Nobili, 1907:359; Kemp, 1917a:324, 393, pl.57, fig.86; Kemp, 1922:285; Rhodesia, 1925:8; 1946:250, fig.151; Ramadan, 1936:23; Kubo, 1940:58, figs.24, 25; Barnard, 1950:801, fig.151, n.o.

Material: 2 specimens. Miniocy Island, Laccadive Archipelago (21-1-1970) 1 male, 8.7 mm; 1 berried female, 11.6 mm; Collected from the coral reef area. Depth of occurrence:2-4 m.

Discussion: The characters by which Kemp (1922) separated Gonodactyus tridacnae Peters, 1852 from G. melanurus Peters 1852 were found to be quite variable by Holthuis (1952) who synonymised the later species with the former. The length of the rostrum, proportion of the carpus and merus of 1st pereopod, nature of the anterolateral angle of basal segment of antennular pedunele, length of the penultimate segment of 3rd maxilliped difference in proportion between breadth and length of merus and propodus of 3rd pereopod and size of the dorsal spine of telson are found to be unreliable in these two species. The teeth on the basal process of dactylus of last three legs are absent in this species unlike in G.granulatus. Rostrum may extend up to end of antennal scale or not. Outer distal angle of antennular segment may be acute or rounded. Carpus of first leg may be as long as, longer than or even shorter than the merus.

G. tridacnae is reported to occur in the lamellibranch Tridacna sp. from various parts of the world. The present specimen was collected from Tridacna sp. from shallow coral reef of Miniocy Island.

Distribution: Red Sea (Nobili, 1906b; Bales, 1915; Patterson, 1967; Ramadan, 1936); Western Indian Ocean (Peters, 1852; Hilgendorf, 1879; Nobili, 1906b; Borradaile, 1917a); Maldive and Laccadive Archipelagoes (Borradaile, 1917a; Kemp, 1922); Gulf of Manaar (Henderson 1893; Thurston, 1895); Ceylon (Pearson, 1905; Borradaile, 1917a); Andaman Island (Kemp, 1922; Chopra, 1951); East Indies (Nobili, 1899); Japan (Kubo, 1940); Australia (Bate, 1888; Miers, 1884; Thompson 1901; Bales, 1921; Kemp, 1922; Mc Neill, 1926); Pacific Ocean (Dana 1852; Miers, 1884; Ortmann, 1890; Borradaile, 1899; Nobili, 1907; Kemp, 1922; Edmondson, 1925; 1946; Boone, 1955; Armstrong, 1941).

Genus Anchistus Borradaile 1898

Anchistus custos is the only species representing this genus in the present material.

Key to the Indian species of Anchistus

1. Rostrum toothless; antepenultimate segment of third maxilliped very broad, contrasting strongly in width with two distal segments; chela of first leg with its lateral edge produced and bent downwards, the lower surface thus being deeply channelled; dactyli of last three legs simple, less than half as broad at base as distal end of propodus. . . . . A. custos (= A. inermis)

   Rostrum with teeth at or near apex; antepenultimate segment of third maxilliped rather slender, not contrasting strongly in width with two distal segmental chela of first leg normal in form; dactyli of last three legs a little narrower at base than distal end of propodus. . . . . 2

2. Dactyli of last three legs normal in form, simple and consisting of a broad basal portion and a slender curved apical claw; basal segment of antennular peduncle with a short tooth at distal end of outer margin antennal spine present . . . . . A. australis

- Dactyli of last three legs spoon-shaped with distal part of upper border reflected inwards, hinguiculate; basal segment of antennular peduncle without terminal tooth. . . . . 3

3. Rostrum more or less pointed with teeth on upper border near apex; antennal spine present; dactyli of last three legs with sharp accessory claw and very minute and inconspicuous spinules . . . . . A. hiemi

- Rostrum squarely truncate with teeth only at the apex; antennal spine absent; dactyli of last three legs with short blunt accessory claw and large spinules. . . . . Acanthomysis

Anchistus custos (Forsskal, 1775)

(Pl.IV, 1-3)

Cancer custos Forsskael, 1775:94.

non Cancer custos Forsskael, 1775:89.

Palaemon custos Latreille 1802:357.

Pontonia custos H. Milne Edwards 1837:360.

Pontonia inflata H. Milne Edwards 1840:633; Tennent 1861:479.

Anchistus custodiens Dana 1852:25; 1852:581; 1855:12, pl.1, fig.3; Weitzenhöfer, 1954:60; Kemp, 1922:249, fig.81.

Acanthomysis inermis Hiere, 1884:291, pl.32,fig.3; Hallen, 1887:471.

*Amphiglena fungida* Borradaile, 1900a:307; 1917a:388; Lanchester, 1901: 355; Pocock, 1905:77; Pathbun, 1914:636; Chidgey, 1921:391, pl.27, fig.4; Kemp, 1922: 249, fig.81; 1925:382; Kemp, 1924:146; Sewell, 1926:121; 1930:798, fig.130a-d; Gravely 1927:137, pl.19, fig.5; Kulo, 1927:37, fig.58; Kubo, 1940:40, figs.15-17.

*Pontonia pinnae* Ortmann, 1894:16, pl.1, fig.3; Borradaile, 1900a:309; 1917a:391; Nobili, 1906:49, pl.4, fig.11; 1906b:65.

*Amphiglena rugata* Holthuis, 1952:103-09; Johnson and Lang, 1966:483-85.

Materials 19 specimens, Middapan Camp, Palk Bay (26-5-67) 1 male, carapace length, 5.5 mm; 1 female, 7.4 mm; (28-6-67) 1 male, 7.2 mm; 1 female, 6.6 mm; Manowaram (5-5-67) 4 males, 5.7 - 6.1 mm; 7 females, 6.5 - 8 mm (3 berried); Kilakkarai (20-6-67) 2 males, 4-2, 7.8 mm, 2 females, 8.5, 9.5 mm. Collected from the shuttle cavities of *Pinna bicolor* Gmelin. Depth of occurrence 1 - 2 m.

Dimensions Rostrum directed downwards, fastigium, eyes height included in lateral view. Antennal scale broadly oval, though narrower anteriorly. Outer maxilliped normal, terminal tooth small without reaching end of lamella. Third maxilliped with longer and broader antepenultimate segment, being about 4 times broader than that of penultimate segment, being about 3 times broader than that of penultimate segment. The structure of chela peculiar as reported by Chidgey (1921) and Kemp (1922) with its dactyl produced in the form of large bent downwards and thickly fringed with long setae on the margin, making the chela a deeply hollowed nature in a longitudinal direction in lateral view.

Colour of live specimens collected from Palk Bay and Gulf of Manaar were orange yellow with minute white dots covering the entire body and legs. Other details of structure agree well with the excellent description given by Kemp (1922). The name Amphithoe insignis (Kemp, 1922) is preoccupied by Gammarus insignis Pennehal, 1775 as pointed out by Holthuis (1952).

Distribution: Red Sea (Nobili, 1906b; Pennehal, 1775; Chilton, 1921); Persian Gulf (Nobili, 1906) Western Indian Ocean (Ortmann, 1894; Barnard, 1936; 1950); Gulf of Manaar (Pearson, 1905; Kemp, 1922; Gravely, 1927); Ceylon (H.Milne Edwards, 1837; Templeton, 1837; Muller, 1837; Kemp, 1922); Andaman and Nicobar Islands (Kemp, 1922; 1925); Mergui Archipelago (Kemp, 1922); Malay Archipelago (Lagebeutar, 1901); Japan (Imbe, 1940); Australia (Miers, 1884; Bathbun, 1914; Hedley 1924; Hale, 1927).

Family Gnathiidae Ortmann, 1890

Key to the genera of Gnathiidae.

Last two joints of the third maxilliped less than half as broad as the antepenultimate joint; the latter about as broad as the joint preceding it. Dactylus of second leg not serrate above; carpus and merus of that leg without anterior spines. . . . . 2

Last two joints of the third maxilliped almost as broad as or broader than the antepenultimate joint; the latter distinctly broader than the joint preceding it. Dactylus of second leg serrate above; carpus and merus of that leg with strong spines on the anterior margin. . . . . 3

Exopod of third maxilliped shorter than endopod. Dactylus of last three legs biunguiculate, without tubercles on the lower margin. Outer antennular flagellum bifid. . . . . Gnathia/lium

- Exopod of third maxilliped much longer than endopod. Dactylus of last three legs ending in a simple claw, with blunt tubercles on the lower margin. Outer antennular flagellum simple. . . . . Onathomyllaidea

3. Outer antennular flagellum normal in shape, thread-like, chelae of second legs broad and flat, but not leaf-shaped. Last two joints of third maxilliped, though broad, not broader than antepenultimate joint. . . . . Phyllognathia

- Outer antennular flagellum deformed by the extreme broadening of the larger part of its joints to a broad, flat, leaf-shaped appendage. Chelae of second legs also leaf-shaped in that the lower border is produced to a large thin flap. Last two joints of third maxilliped distinctly broader than the antepenultimate joint. . Eurycercus.

Genus Eurycercus Latreille 1819

Eurycercus glacialis Keller, 1861

(Pls.IV, 28-30; XII, 1)

Eurycercus glacialis Keller, 1861:264, fig.9-14; Hilgendorf, 1878:828; de Man, 1902:822, fig.52; 1920:191-92; Nobili, 1906:69; Burnsdaile, 1917:410; Simonsen, 1923:30-33; fig.2 a-j, fig.3, b-f; Barnard, 1946:390.

Material 1 specimen. Kadamat Island, Laccadive Archipelago (20-10-69) Female carapace length, 39 mm. Collected from Coral reefs. Depth of occurrence: 3 m.

Remarks. Though the characters agree with the description given by de Man (1920) there are certain differences probably due to the difference in the age of the specimen. The rostrum in the present specimen reaches upto the base of the third antennular segment, while in the specimens collected by the Siboga Expedition, it reaches only beyond the middle of the second segment. There are 7 teeth on the dorsal and 2 on the lower side of rostrum, posterior two of the dorsal teeth on the carapace the third situated above the posterior border of the orbit. The posterior teeth of the ventral teeth is just in front of the distalmost dorsal teeth.

Telson is 1/7.5 the total length, its maximum breadth being only a little less than its length, and bears two pairs of spines laterally and terminates in a strong spine. On either side of this terminal spine is a short outer and a long inner spine. The outer one of these is 1/3 the length of the inner spine. In between the median spine and the inner large spine is a seta. Uropods are longer than telson. Uropodal exopodite is shorter and narrower than the inner one and bears terminal spine and an extra inner spine at the outer margin of the transverse suture.

The inner antennular flagellum is foliaceous while the outer one is short and whip-like and a little longer than half the length of the inner flagellum. The three distal segments of the endoped of the 3rd maxilliped are expanded. Pleopods have round tips; endoped are broader, less than $\frac{1}{2}$ broad as long while the exoped are narrow and a little more than twice as long as broad. This again is a character in which this specimen differs from the 'Siboga' material. It is probable that the more slender rami of young specimens may become broader as the specimens grow so that they serve to enclose the entire eggmass as it is seen in the preserved material. The present specimens agree with Kubili's (1936)

description of ovigerous specimens collected from Djibouti in the structure of the pleopods, antennular peduncle and third maxillipeds.

Colour: Freshly preserved specimen are cream coloured with brown shade on the middle of rostrum and its base. There are yellow dorsal bands across the 1st abdominal segment, becoming bright orange colour towards the pleura. These bands are lighter towards the posterior segments. The 5th segments are white, 6th yellow, while telson is whitish. Inner uropod yellow tipped, outer being white. Pereopods with yellow and brownish bands on the segments. Pleopods are white.

Distribution: Red Sea (Heller, 1861; Nobili, 1906); Western Indian Ocean (Hilgendorf, 1878; Borradaile, 1917); East Indies (Ortmann, 1890; de Man, 1902, 1920); Pacific Ocean (Edmondson, 1925).

This is the first record of the species from the Laccadive Archipelago.

Family Hippolytidae Bate 1888

Genus Saron Thallwitz 1891

Saron marmoratus (Olivier, 1811)

(Pl.XXI, 2)

Palaemon marmoratus Olivier, 1811:663.

Saron marmoratus Borradaile, 1898:1009; 1902:413; Kemp, 1914:84-87; 1916:385; Stebbing, 1914:34; Boone, 1935:187, pl.51; Gurney, 1937:390, fig.106-12; Kubo, 1940:80, figs.5, 6; Holthuis, 1947:25-29 (Synonymy); Barnard, 1950:688-90, fig.128a, b; Sankolli, 1962:106-120.

Saron gibbosus de Man, 1897:858, pl.XXVI, fig.57; Nobili, 1906a:40; 1906b:35; Coutiere, 1910:71.

Nauticaris grandirostris Pearson, 1905:79, pl.1, fig.6.

Salmoneus pennocrinis Rathbun, 1906:915.

Materials: 85 specimens. Minicoy Island, Laccadive Archipelago (12-1-1967) 3 males, carapace length, 4.3 - 10 mm; 1 berried female 7 mm; Kavarathy Island (18-3-65) 4 males 5 - 7 mm; 3 berried females 7 - 9.1 mm; Chetlat Island (9-3-65) 5 males 4.2 - 8 mm; 2 berried females 8, 10.3 mm; Kilpeni Island (25-3-65) 3 males 5.9 - 6.6 mm; 5 berried females 7 - 9 mm; Agathi Island (15-12-64) 1 male, 13.8 mm; Kadamat Island (13-10-69) 1 male 6.6 mm; 3 females 5.8 - 6.8 mm. Collected from the coral reefs. Depth of occurrence 1 - 3 m.

Discussion: The variability of the length of the third maxilliped and the first periopod in male specimens is noticed in the present material also. As Kemp (1914) has remarked this cannot be considered as a sort of sexual dimorphism of males. Most of the specimen bear coarse tufts of hairs on the rostrum, carapace and abdomen.

Distribution: Red Sea (Heller, 1861; Roesmann, 1880; Nobili, 1906a & b; Lenz, 1912; Balss, 1915; Ramadan, 1936; Gurney, 1957); Persian Gulf (Nobili, 1906a; Kemp, 1914); West coast of India (Kemp, 1914; Sankolli and Kewalramani, 1962); Western Indian Ocean (Ortmann, 1894; Hilgendorf, 1879; Coutiere, 1900; Lenz, 1905; Richters, 1880; Kemp, 1914; Borradaile, 1917); Laccadive Archipelago (Borradaile, 1917); Gulf of Mannar (Kemp, 1914; Crevely, 1927); Ceylon (Pearson, 1905); East coast of India (Kemp, 1914); Andaman and Nicobar Islands (Heller, 1865; Kemp, 1914, 1916); Philippines (Thalwitz, 1891, 1892); Japan (Balss, 1914a; Parisi, 1919); East Indies (de Man 1897; Borradaile, 1899); Australia (Olivier, 1811; Lamarck, 1818; H. Milne Edwards, 1837b, 1838; White, 1847a, Kemp, 1865; Haswell, 1882; Kemp, 1914; Mc Neill, 1926; Boone, 1935);

New Zealand (Coutiere, 1900); Pacific Ocean (H.Milne Edwards, 1837; Randall, 1839; Dana, 1852; Heller, 1865; Ortmann, 1890; Sharp, 1893; Coutiere, 1900; Rathbun, 1906; Peeta, 1914; 1953; Edmondson, 1923; Kubo, 1940).

Genus Hippolysmata, Stimpson 1860

There are only two species representing this genus viz. H. vittata and H. ensirostris.

Key to Indian species of Hippolysmata.

Rostrum shorter than carapace, without elevated basal crest; pterygostomian spine, if present, smaller than antennal; lateral margins of telson convex, apex blunt with a pair of spines. . . . . 2

Rostrum longer, usually very much longer than carapace, with an elevated dentate basal crest; pterygostomain spine as large as antennal; lateral margins of telson concave, apex acute and unarmed. . . . . 5

Rostrum not reaching beyond second segment of antennular peduncle, inferior margin with 2-4 teeth; dactylus of last three pereopods terminating in two large claw-like spines. . . . . 3

Rostrum reaching beyond antennular peduncle, inferior margin armed with 6-7 spines; dactylus of last three pereopods simple. . . . . H. dentata

A minute spine at antero-lateral angle of carapace; fingers of first pereopods, when closed, meeting only at tips. . . . . 4

No spine at anterolateral angle of carapace, fingers of first pereoped, when closed, meeting throughout their length. . H. kukenthali

4. Second pereopods symmetrical, carpus composed of 15 - 24 segments. . . . . H. vitiata.

5. Carapace smooth or sparsely punctate laterally, depression between branchial and cardiac regions usually obscure; basal crest of rostrum with 7-12 teeth; fifth pereopods not extending beyond antennal scale. . . . . H. empiricetris.

Hippolysmata (Exhippolysmata) empiricetris Kemp, 1914

Hippolysmata empiricetris Kemp, 1914:118-20, pl.7, fig.1-4; 1916:403-04, fig.5; de Man, 1929:188, fig.7; Balss, 1933:85; Kurian, 1953:760; Banner and Kartha, 1967:736-43; Rao, 1969:86.

Hippolysmata (Exhippolysmata) empiricetris Holthuis, 1947:74-75.

Materials 45 specimens. Bombay (13-11-67) 11 females, carapace length, 10.5 - 17 mm; Calicut (18-3-65) 1 berried female 15 mm; Ashecode (4-4-67) 1 male, 9.8 mm; 21 females, 9.1 - 15.5 mm (berried also); Vedalai, Gulf of Mannar (10-11-66) 8 females (2 berried) 8.4 - 11.1 mm; Nagapattinam (2-3-67) 2 females, 9.8, 9.9 mm; Cuddalore (27-2-67) 1 female, 9.5 mm. Collected from stake net, shore seine and trawlnet catches. Depth of occurrence: 2 - 15 m.

Remarks: The specimens agree well with the original description of Kemp (1914). The characteristic shape and dentition of the rostrum with its crest at the base and closely arranged sharp teeth on the dorsal side makes it easily distinguishable from the allied Indian forms. Rostrum longer than carapace, with 11-16 dorsal teeth, 7-12 of which are situated on the elevated crest. Lower margin with 7-16 teeth. Antennular peduncle almost reach 2/3

of cephalocarite. Antennal flagellum very long, about twice as long as the entire body of the animal. Epipod much reduced on first 4 pairs of legs. Telson with 2 pairs of dorsal spinules, without terminal spinules and extending beyond the end of uropods. Although the species has been collected from the entire west and east coasts of India it forms a fishery of varying magnitude only in Gujarat, Maharashtra, Andhra and West Bengal.

Distribution: West coast of India (Kemp, 1914; Kurian, 1953; Ramamm and Kartha, 1967); Ceylon (Kemp, 1914); East coast of India (Kemp, 1914; 1916; Rao, 1966); Burma (Kemp, 1914); East Indies (de Man1929; Balss, 1933; Holthuis 1947).

This species is reported from the Gulf of Mannar for the first time.

Genus Hippolyte Leach 1814

Hippolyte ventricosa Milne Edwards, 1837

(Pl.IV, 13-15)

Hippolyte ventricosus Milne Edwards, 1837:371; Kemp, 1914:96, pl.2, figs. 1-3; 1916:391; Gurney, 1927:391, figs.94, 95; Holthuis, 1947:55-58, figs.7-9 (Synonymy.)

Hippolyte orientalis Heller, 1862:277; Lenz and Strunck, 1914:319; Balss, 1927:223; Gurney, 1927a:229.

Hippolyte orientalicnsis Kemp, 1914:98, pl.2, fig.6; Nale, 1927b:90, fig.42; 1928:91, fig.19.

Virbius australiensis Stimpson, 1860:35; Haswell, 1882:186; Whitelegge, 1890:224.

Virbius mossambicus Hilgendorf, 1879:836, pl.4, fig.1.

Virbius orientalis Lenz, 1912:2.

Sunidia sinuinsulis Bate, 1863:500, pl.40, fig.3.

Materials Several specimens. Mandapam Camp, Gulf of Mannar (14-2-67) 4 females (2 berried) carapace length 1.8 - 2.5 mm; 7 males, 1.5 - 2 mm; Thonithurai, Gulf of Mannar (20-2-67) 30 berried females 2 - 3.5 mm; 14 males, 1.8 - 2 mm; Mandapam Camp, Palk Bay (27-1-67) 10 males 2.5 - 3.6 mm; 22 berried females 4.1 - 4.8 mm; (14-4-67) several males, 2.2 - 3.1 mm; several females (berried also) 3.2 - 5.1 mm; Collected from seaweeds. Depth of occurrence half to one meters ($\frac{1}{2}$ to 1 m).

Discussion: The specimens collected from Gulf of Mannar from seaweeds in the shallow water were of smaller size ranging in length (carapace length) 2 - 3.5 mm as observed by Holthuis (1947). Rostrum with 1 - 2 dorsal teeth and 2 - 3 ventral teeth in ovigerous females while in males there were 0 - 2 teeth dorsally and 1 - 2 teeth ventrally. Second and third segments of antennular peduncle short and broad, the end being broader than long. Antennal scale was less than three times as long as broad. Propodus of 3rd maxilliped was half the length of dactylus. Third segment of carpus of second pereiopod were longer than second segment and as long as the first. Since the variable characters of the Malayan specimens collected by Siboga Expedition are intermediate between the extremes found in S.sinuinsulensis and S. ventricosa the variations in these characters can be considered due to the wide distributional range of the species, as pointed out by Holthuis (1947).

The male specimens have penelopods, with the dactylus flanging back over the broadened anterior part of the propodus. As Chace (1957) has observed this is a special adaptation for prehensile purposes.

Distribution: Suez Canal (Nales, 1927; Gurney, 1927a, b); Red Sea (Heller, 1868a; Lenz, 1912; Holthuis, 1947); Asiatic seas (H.Milne Edwards, 1837b); East Africa (Hilgendorf, 1878); Gulf of Manaar (Kemp, 1940); Andaman Island (Kemp, 1916); Indian Ocean (Lenz and Strunck, 1914); East Indies (Holthuis, 1947); Australia (Stimpson, 1860; Bate, 1863; Whitelegge, 1890; Kemp, 1914; Coulon, 1918; Nale, 1927b, 1928).

## Genus Latreutes, Stimpson 1860

Two species of the genus viz. L. pygmaeus and L. mucronatus were collected during the present studies from the shallow water sea weeds.

### Key to the Indian species of Latreutes

1. Dactyli of last three pairs of pereopods with conspicuous spines on margin. . . . . 2

- Dactyli of last three pairs of pereopods simple claws, without spines on margin. . . . . L. anoplonyx, Kemp.

2. Form very slender, basal segment of antennular peduncle three times as long as wide, antennal scale more than six times as long as wide; legs short, second pair not reaching to end of eyes. . . . . L. pygmaeus, Nobili

- Form stouter, basal segment of antennular peduncle twice as long as wide, antennal scale not more than four and a half times as long as wide (less in adults); legs longer, second pair reaching beyond end of antennular peduncle. . . . L. mucronatus, Stimpson

**Latreutes** [illegible] Nobili, 1904

(Pl.IV, 16-18)

**Latreutes** [illegible] Nobili, 1904:230; 1906a:37, pl.3, fig.4, a-h; 1906b:41; Kemp, 1914:99-101, pl.2, fig.7, 8; pl.3, figs.1-7; 1916:396-97; Ealea, 1921:10; Barnard, 1947:385; 1950:707-08, fig.131, e.

**Material:** 6 specimens. Thonithurai, Gulf of Mannar (11-6-1968) 6 females, carapace length, 2·9-3·0 mm. Collected from seaweeds. Depth of occurrence 0 - 1 m.

**Remarks:** Rostrum distally, with 1-3 teeth on the dorsal and 2-5 teeth on the ventral surfaces. There is a small conical process close to the cornea near the inner aspect of the eyestalk. Antennular peduncle reaching a little more than the middle of the antennal scale. The dorsal antennular flagellum [illegible] the middle and ventral flagellum reaching tip of the antennal scale. Basal segment of antennule three times long as broad. Lateral process at the base rounded and feebly bilobed. Anterior end bearing pointed lateral process, [illegible] the outer side, the length of being about the same as the breadth of the basal antennular segment. Second segment of the carpus of 2nd leg longest of the three. Dactyli of the last three legs terminating in sharp [illegible] spines. A few smt other spines on the posterior margin.

[illegible] of berried females varied in diameter from 0.317 - 0.334 mm. There [illegible] eggs in a single female measuring 15 mmin total length.

[illegible] live specimens collected from seaweeds were green in colour.

[illegible]: Red Sea (Nobili, 1904, 1906b); Persian Gulf (Nobili, 1906a); [illegible] (Barnard, 1947, 1950); Gulf of Mannar (Kemp, 1914); Andaman [illegible] Kemp, 1916); Australia (Ealea, 1921).

## Latreutes mucronatus (Stimpson, 1860)

(Pl.IV, 19 - 23)

Rhynchocinetes mucronatus Stimpson, 1860:28.

Latreutes serrivai Nobili, 1904:231; 1906a:39, pl.3, fig.5; 1906b:41.

Latreutes mucronatus Balss, 1914a:47, fig.27; 1921:10; Kemp, 1914:101, pl.4, fig.1, 2; 1916:396; Urita, 1926:427; Boone, 1955:195, pl.55; Yu, 1955:50; Holthuis, 1947:60; Kurian, 1953:760.

Latreutes mucronatus multidens Nobili, 1905c:395; 1906b:41, pl.2, fig.3.

Materials 1 specimen. Mandapam Camp, Palk Bay (27-1-67) 1 berried female, carapace length, 4 mm; Collected from seaweeds. Depth of occurrence ½ - 1 m.

Dimensions Stout form with more or less circular rostrum (rostral formula 1) $\frac{10}{10}$). The rostrum reaching almost to the tip of the antennal scale. Dorsal and ventral teeth are borne only on the distal half. The strongly arched carapace without median carina but bearing a strong, curved and pointed fixed tooth behind the base of the rostrum. The antennal tooth is present. Six small spines on the anterolateral margin of the carapace.

The eyestalk wider than the cornea and with a short conical projection towards inner distal aspect. Antennular peduncle reaching, a little short of the middle of antennal scale. Breadth of basal segment of antennule less than half its length. Lateral process of base of antennule rounded and entire.

Third maxilliped reaching the tip of the carpocerite. 1st leg reaching the base of antennal scale, 2nd to tip of antennular peduncle, 3rd beyond tip of antennular peduncle, 4th to tip of cornea and 5th to base of scaphocerite.

Carpus of 2nd leg with proximal and distal segments of equal length and middle segment twice length of first. Knotyli of last three pairs of pereiopods as in A. nymphaea.

Sixth abdominal segment twice as long as the fifth. Telson with two pairs of spinules and ending distally in a pointed process. Two pairs of spines on either side of the median process. Median process less than half as long as the inner spine. The outer spine still smaller and almost equal in length to the dorsal spinules. Inner uropod longer than the outer. Tip of outer uropod tapering while that of inner one broader towards the extremity.

Distribution: Red Sea (Nobili, 1904, 1905a, 1906b); Arabian coast (Nobili, 1906a); Gulf of Manaar (Kemp, 1914); Andaman Island (Kemp, 1916); Gulf of Siam (Balss, 1914a); Japan (Balss, 1914); China (Yu, 1935); Korea (Balss, 1914a); Hong Kong (Stimpson, 1860); East Indies (Nobili, 1906b; Boone, 1935); Australia (Balss, 1921).

## Family Alpheidae Rendall, 1839

### Key to the Indian genera of Alpheidae

1. Cornea of eye at most only partially concealed from anterior or lateral view by carapace; dactylus of large chela without plunger fitting into socket of fixed finger and often bearing teeth. . . . . 2

   Cornea of eye entirely covered in dorsal lateral and anterior view by orbital hood, an overgrowth of the anterior carapace; dactylus of large chela usally with a plunger that fits into a socket of the fixed finger, never serrate. . . . . 5

2. Entire eye stalk exposed; cornea reduced. . . . . Autonata.

- Peduncle of eye covered; cornea usually well developed. . . . . 3

3. Cornea of eye exposed in dorsal and lateral view. . . . Athanas.

- Cornea largely or entirely concealed in dorsal view, partially or entirely concealed in lateral view. . . . . 4

4. Rostral front broadly triangular; large chela carried folded back against the merus; tip of telson with 'v'-shaped notch. . Salmoneus

- Rostral front narrow; large chela carried, extended tip of telson truncate or convex. . . . . Alpheopsis

5. Carapace strongly compressed, with elongate dorsal keel that is interrupted by a deep notch immediately behind the orbital hoods. . . . . Racilius

- Carapace not compressed; dorsal keel, if present not strong and without a deep notch behind the orbital hoods. . . . . 6

6. With pterygostomial margin produced into a definite angle; without anal tubercles; without mastigobranchs and setobranchs. . . . . Synalpheus

With pterygostomial margin rounded, never angular with anal tubercles; bearing mastigobranches and setobranchs at least on anterior thoracic legs. . . . . Alpheus

Genus Athanas Leach, 1814

Athanas dorsalis (Stimpson, 1861)

(Pl.XII, 3)

Arete dorsalis Stimpson, 1861:32

Athanas mascarinicus Richters 1880:164

Arete dorsalis var. pacificus Coutiere, 1903:87, figs.31-34.

Alpheus mentiensis Coutiere 1904a:19, figs.1-6.

Alpheus mentiensis var. sulcimanensis, de Man, 1910a:913:1911:169, pl.4, fig.13.

Athanas dorsalis Banner and Banner, 1960:151-54; Sankarankutty, 1963: 167-71.

Material: 5 specimens. Mandapam Camp, Gulf of Mannar (14-10-68) 2 males, carapace length, 5.2, 5.5 mm; (6-7-69) 1 male, 5.6 mm; Miniecy Island (20-8-70) 1 male, 6.1 mm; 1 berried female, 6.85 mm. Collected from the outer surface of the black sea urchin, Stomopneustes variolaris (Lamarck). Depth of occurrence 1 - 2 m.

Dimensions: Rostrum broadly triangular, extending to middle of second antennular segment, without dorsal carina and orbitorostral groove. Stylocerite elongated, reaching middle of last segment antennular peduncle. Antennal scale falling a little short of the tip of antennal peduncle and with a well developed outer terminal spine, extending a little beyond the tip of the spine. Inner antennular flagellum as long as carapace, outer one only half its length.

Larger chela with short ischium broader than long with a spine each on the outer and inner border, anteriorly. Merus 2.2 times long as broad, carpus as long as broad and palm longer than fingers which cross at the pointed, curved tips.

Telson less than 4 times as long as breadth of posterior margin.

Colour: In life the colour is black as that of the sea urchin. In freshly preserved condition the colour becomes lighter, a deep chocolate colour, with lighter yellowish band on the lateral side of body. There are light

nds across the chelipeds and one along the long axis of the chela. he antennular flagella are yellowish. The setae on the appendages re white.

Distribution: Indian Ocean (Richters, 1880, Coutier, 1903, 1905a); ulf of Manaar (Sankarankutty, 1963); Indonesia (de Man, 1910a, 1911); ong Kong (Stimpson, 1861); Pacific Ocean (Banner and Banner, 1960).

## Genus *Alpheus* Fabricius 1798

### Key to the Indian species of *Alpheus*

1. Orbital teeth absent; merus of 3rd leg with an acute teeth. . . . 2
   Merus of 3rd leg without an acute teeth. . . . . 3
2. Dactylus of large chela hammer-shaped; 2nd carpal article usually 3 times as long as 1st article; Squamous portion of cephalocarite reaching only to near middle of 2nd antennular article.. *A. chercheurs*
   Dactylus of large chela usually heavy, but not hammer-shaped; merus of 3rd leg without setae; 1st carpal article of 2nd leg about 1.5 times length of 2nd article. . . . . *A. hippothoe*
3. Dactylus of third legs flattened on inferior surface, subspatulate in form. . . . . 4
   Dactylus of third legs simple and conical. . . . . 7
4. Superior margin of palm of large chela only with narrow notch; palm without extensive depressions. Fingers of large chela heavy, blunt and in line with axis of chela. . . . . *A. [illegible]*
   Notch of superior margin of large chela broad and continous with extensive saddle-shaped depression on palm. . . . . 5

5. Small chela of both sexes with fingers, equal to or shorter than palm; propodus of third leg with several movable spinules but without heavy setae. . . . . A. sumbawanus

- Small chela with fingers markedly longer than palm; propodus of third leg without spines but bearing heavy setae. . . . . 6

6. Small chela with fingers straight and 3 times length of palm. . . . . A. malaharicus malaharicus

- Small chela with fingers hooked and crossing, about 1.5 times as long as palm. . . . . A. malaharicus gentilis

7. Rostral base between orbital hoods flattened, with margins overhanging orbito-rostral grooves. . . . . 8

- Rostral base between orbital hoods rounded to carinate with curve of margins continuous with orbitorostral grooves, not overhanging. . . . . 9

8. Orbital hoods anteriorly rounded; rostral base narrow, rostrum a narrow triangle; depression on faces of large chela saddle-shaped. . . . . A. bigniesius

9. With lateral spine of basiocrite reaching to near middle of second antennular article; outer face of palm of large chela with only slight longitudinal groove. . . . . A. parvirostris

- With lateral spine of basiocrite, if present, small, and not reaching to end of first antennular article, rostrum narrowly triangular and reaching to or beyond middle of visible part of antennular article; first carpal article of second legs at most 2 times length of second article; depression on outer face of large chela extensive and roughly quadrangular; fingers of small chela of female roughly equal in length to palm, those of male definitely shorter. . . . . A. grandimanus

## *Alpheus rapax* Fabricius 1798
(Pl. IV, 28-30, XII,4)

*Alpheus rapax* Fabricius, 1798:405; Coutiere, 1899:253, fig.284; de Man, 1909b:147, pl.7, figs.1-8; Banner and Banner, 1966:121-123, fig.44.

*Alpheus malabaricus* Hilgendorf, 1878:832.

*Alpheus brevirostris* de Man, 1888:261.

**Material:** 2 specimens. Rameswaram (19-2-68) 1 male, carapace length, 17.9 mm; Mandapam Camp, Palk Bay (25-7-68) 1 male, 7.8 mm. Collected from burrows shared by gobiid fish. Depth of occurrence 1 - 2 m.

**Diagnosis:** Rostrum acute reaching almost to the base of 2nd antennular segment. The rostral carina well developed reaching backward to the base of orbital hood. Orbito-rostral groove well developed. Stylocerite leaf-like, extending to tip of 1st antennal joint. Scaphocerite expanded near the base and with curved outer margin. Lateral spine a little longer than the squame, antennal peduncle reaching carpocerite.

The compressed large chela roughly quadrangular in cross section, 2.5 times as long as broad, unlike the material collected from Thailand by Banner and Banner (1966). Fingers with thickly set rows of setae on the opposing edges. Manus only twice as long as broad. Inferior internal margin with 6 movable spines and ending in a strong tooth. An excavation near the lower rounded portion of the palm, proximally, on the outer aspect.

Small chela compressed, 3.8 times as long as wide, opposing flattened faces of fingers with thick rows of bristles, tips hooked. Manus 2.5 time as long as wide with 7 movable spines on the internal inferior margin.

Telson twice as long as breadth of posterior rounded margin.

Colour: Dark and light transverse bands present across the cephalothorax and abdomen. Large chela has similar transvers markings, distinct on the inner side. The tips of the fingers are white. In the living condition the white bands are very clear on the Ist abdominal segment, dorsally on the anterior end.

These alpheids were found to occur in burrows shared by a gobiid fish living in sandy and slightly muddy areas with dead coral pieces. They were quick in retreating into the burrow on the slightest disturbance. But when once the burrow was blocked they became very passive and could be easily collected by a hand net.

A pair of these animals were collected from Palk Bay and kept in the laboratory for observation in a glass trough with sand at the bottom. Although they were put away from each other, within a few minutes the alpheid was found digging the sand near the margin of the trough, with the gobiid by its side, as a passive observer. The alpheid collected sand grains between its chelae and pushed forward and after a few minutes turned backwards and started fanning with the pleopods, blowing the sand off, thus deepening the depression already formed. When some pieces of stones and shells were put as cover them they hid beneath them. The shrimp was observed to plug the opening of the burrow by dragging in algae put in the trough.

Distribution: Red Sea (Coutiere, 1899); east Africa (Hilgendorf, 1878); Maraui Archipelago (de Man, 1888a, 1909b); Thailand (Banner and Banner, 1966).

## Alpheus malabaricus gemikla Banner and Banner 1966

(Pl.IV, 35 - 38)

Alpheus malabaricus gemikla Banner and Banner 1966:147-49, Fig.36.

Materials 6 specimens. Korapuzha estuary (11-6-65) 2 males, carapace length, 15.5, 16.6 mm; 2 females, 14.2, 17 mm; Mundapam, Palk Bay (11-7-66) 1 female, 18.6 mm; (23-10-68) 1 berried female 20 mm. Collected from stake net and trawl catches. Depth of occurrence 5 - 10 m.

Discussions The characters of the specimen collected during the present studies conform to those described earlier by Banner and Banner (1966).

Rostrum setute, reaching middle of visible part of Ist antennular segment. Carina not prominent, not reaching posterior base of orbital hoods. Orbital grooves shallow. 2nd antennular article 2.2 as long as broad, visible portion of Ist segment 1.3 times as long as 3rd segment; 0.7 as long as 2nd segment. Tip of stylocerite not reaching tip of 2nd segment of antennular peduncle. Outer margin of scaphocerite straight, spine reaching tip of 3rd antennular article; but not to the tip of the scaphocerite. Carpocerite longer than antennular peduncle.

Large chela 2.4 times as long as broad, finger 0.3 length of entire chela. The proximal margin of the shallow transverse groove of the upper margin perpendicular to the long axis of the chela, the distal margin being inclined and rounded. Depressions of the outer and inner surface of big chela roughly triangular and poorly delimited. Merus 2 times as long as broad.

Small chela with crossing fingers, length 4.4 times its breadth, fingers 1.5 times length of palm. Upper distal margin of palm slightly

projecting. Outer margin of fingers with dense setae. Ischium of 3rd leg with a movable spinule, merus 4.4 as long as broad, unarmed; carpus 0.6 as long as merus, propodus 0.9 as long as merus. Long setae present near the upper margin of propodus in addition to three spinules near the proximal end, placed equidistantly.

Colours: In fresh specimen general body colour is cream with dark brown cross bands along posterior margins of abdominal segments and carapace, tips of uropods and the anterior border of carapace between orbital hood and lateral angle dark brown. Antennal flagella are bluish violet while antennular flagella have brownish tinge. Chelipeds are grey with inner dipress one of large chela violet, remaining part of chela and legs being pinkish. Exopods and endopods of chelipods are bright red with paler bases, while the under surface of abdomen and chela are white.

The species is not so common as Alpheus distinguendus in the commercial prawn catches.

Distribution: Thailand (Banner and Banner, 1966).

This is the first report of the species from outside the type locality in Thailand thus extending the geographical distribution to the west and east coasts of India.

Alpheus gracilimanus Heller 1865

Alpheus gracilimanus Heller, 1865:107, pl.10, fig.2; Bate, 1888:554, pl.99, fig.2; de Man 1902:880, pl.37,fig.61; 1911:417-18; Barnard,1950:756,fig.144; Banner, 1959:147,fig.11; Banner and Banner,1966:138-40, fig.52.

[redacted] Banner, 1953:134, fig.49.

[redacted] Several specimens. Tuticorin (23-8-70) 2 males, carapace length 10, 10.1 mm; 6 females (2 berried) 10.7-12.5 mm; Mandapam Camp, Gulf of Mannar (28-12-68) 1 male, 9.7 mm; 1 berried female, 7.8 mm; Rameswaram (5-9-67) 2 males, 8, 13 mm; 5 females (2 berried), 6.5-14 mm; Mandapam Palk Bay (26-11-66) 2 males, 11, 11.2 mm; (3-12-66) 4 males, 5.9 - 9.9 mm; 6 females (4 berried), 6-10.2 mm; (13-2-67) 14 males, 6.5-11.2 mm; 33 females (26 berried) 5-9 mm. Collected from shore seines and dead coral blocks. Depth of occurrence 2-6 m.

[redacted] The material collected from various localities agree with the descriptions given by earlier workers although high degree of variation is exhibited in many characters.

The large chela with characteristic shoulders and depressions. Manus about twice as long as broad unlike the specimens reported from Thailand (Banner and Banner, 1966). Small chela of male with dactyli of typical halaeniceps shape. Slender small chela of female with fingers as long as palm; manus twice as long as broad. 3rd leg bearing a movable spine on ischium and 7 large movable spines on the propodus.

The species is the most common alphied in Palk Bay and Gulf of Mannar. They were collected in large numbers from below coral blocks in sandy and muddy intertidal areas. Specimens were also collected from dead coral blocks from coral reefs fringing the neighbouring islands in the Gulf of Mannar.

The colour varied from pale yellow with orange chelae having darker tips of fingers to olive green. Eggs were green in colour in early stages which turned to greenish brown as development proceeded.

Distribution: South Africa (Barnard,1950); Nicobar Island (Heller,1865); Thailand (Banner and Banner,1966); East Indies (de Man 1902; 1911); Pacific Ocean (Banner, 1959).

## Alpheus sunbreyma de Man 1897

(Pl.IV, 33,34,XXI,5)

Alpheus sunbreyma de Man, 1897:745,pl.36,fig.6; 1898:317,pl.4,fig.2;
Banner and Banner 1966:130-33,fig.49.

Synalpheus sunbreyma Servatti 1957:48.

Materials 8 specimens. Tuticorin (5-4-68) 1 male, carapace length 18.7 mm; Mandapam, Gulf of Mannar (11-7-66) 2 males, 16.5, 22.6 mm; 2 females, 19.5, 18.1 mm; Rameswaram (12-4-69) 2 males, 19, 18.5 mm; Pamban, Palk Bay (25-11-67) 1 male, 21.2 mm. Collected from trawl catches. Depth of occurrence 10-15 m.

Discussions: The specimens collected during the present investigations agree well with the description given by Banner and Banner (1966). Large chela is very massive, rather cutsized in comparision with the carpus and merus, and conforms to the detailed description by Banner and Banner (op.cit). But the small chela in male bearing balaenicepe dactylus is only about 3.5 times its breadth unlike the Thailand specimens reported by them. The dactylus is longer and the sharp tip cross over the tip of fixed finger. Merus, unlike that of Thailand specimens is only 2.3 times, as long as broad. Female chela is more slender, about 4 times as long as broad. Ischia of 3rd and 4th legs of female with movable spines situated in a depression on the ventral aspect near the proximal part. The unarmed merus is only less than 5 times as long as wide being not much elongate as in Thailand specimens. Carpus is a little

longer than half the length of merus, propodus less than 0.8 as long as merus and bearing 3 movable spinules on its proximal half in addition to the single spinules at the distal end on the inner aspect while the carpus of the 4th leg bears 5 spinules extending along 2/3 of its length, besides the distal one. Telson has the sides almost straight with a rounded posterior margin. Outer to the middorsal groove are the paired short and stout dorsal spines. The length of the telson is 1.6 times its breadth at the posterior end.

The male specimen from Mandapam measuring 22.6 mm in carapace length (71 mm total length) is the largest specimen so far reported.

Ground colour of fresh specimens was cream to pale yellow with dark cross bands on the posterior margins of carapace and abdominal segments. Chelae with violet patches on the depressions and tips. Antennal and antennular flagella also violet in colour. Legs and setae whitish.

Distribution: Thailand (de Man, 1898; Suvatti, 1937; Banner and Banner, 1966); East Indies (de Man, 1897).

The present report of this species, forthe first time from southeast coast of India, extends its distribution considerably.

## Alpheus distinguendus de Man, 1909

(Pl.IV, 31, 32; XII,6)

Alpheus distinguendus de Man, 1909:153, pl.7, fig.15,16; 1911:324(Key)
Alpheus rugus de Mann, 1910:197, pl.45, fig.2.

Material: Several specimens. Tuticorin (5-4-68) 1 male, carapace length 5.5 mm; (23-8-70) 9 males, 11 - 14 mm; 1 female, 12 mm; Vedalai, Gulf of

Mannar (15-8-67) 2 females, 20.2, 22.5 mm; Rameswaram (23-9-67) 1 male, 22.9 mm; (14-8-68) 11 males 20.5 - 25 mm; 1 female, 22.6 mm; Mandapam, Palk Bay (25-5-67) 9 males, 16.1 - 23.8 mm; 2 females 17.5, 23.5 mm; Cuddalore (9-11-68) 3 males 23.1 - 24.3 mm. Collected from shore seine and trawl catches. Depth of occurrence 2 - 10 m.

Diagnosis: Rostrum pointed, dorsal crest extending backward separated from orbital hood by a well defined orbitorostral groove. Rostrum falls short of the tip of the 1st antennular segment. Stylocerite as long as the tip of rostrum. Scaphocerite with straight outer margin. Antennular peduncle slightly longer than carpocerite.

Larger chela without transverse groove near the base of dactylus; dactylus of smaller chela of male not 'Palaemonopsis' shaped. Palm of smaller chela of male not longer than high, without transverse grooves; fingers in adult specimens 2.5 times.

Telson elongated 2.5 times as long as the breadth at the posterior end which is rounded.

General body colour ash grey with white patches. Larger chela with colour markings only on the inner aspect. 1st legs violet in colour. Ventral surface pale yellow to whitish.

This species is the most common alpheid shrimp occurring in the shrimp trawl catches from Gulf of Mannar and Palk Bay.

Distribution: Japan (de Man, 1930); East Indies (de Man, 1909).

This is the first record of the species from Indian Region, extending the distribution considerably to the western part of the Indo-Pacific.

## Section Anomura

Three families viz., Diogenidae, Paguridae and Coenobitidae are dealt with in the present account.

## Key to families

1. Uropods present; penultimate pair of thoracic legs much shorter than those in front of them. .. .. .. 2
- Uropods absent; carapace crab-like; penultimate pair of thoracic legs at least as well developed as those in front of them. Lithodidae
2. Abdomen straight and perfectly symmetrical all its terga well developed and in contact; with 5 pairs of symmetrical appendages in addition to uropods. .. .. Pylochelidae
- Paired appendages never present on all abdominal somites. .. 3
3. Antennular flagella end in a filament. Antennular peduncles rarely approach carapace in length. .. .. 4
- Antennular flagella end abruptly and bluntly; peduncles nearly as long as or even longer than carapace. .. Coenobitidae
4. Bases of 3rd maxillipeds approximated. .. Diogenidae
- Bases of 3rd maxillipeds widely separated. .. Paguridae

## Family Diogenidae Ortmann, 1892

The most important distinguishing character of this family is the third maxillipeds with approximated bases. Chelipeds are equal or subequal or the left vastly larger; very rarely right slightly, never vastly larger than the left.

Eight genera consisting of 31 species belonging to this family were collected during the present studies.

Genus Paramunnopsis Henderson, 1893

Carapace elongate, gastric and cardiac regions very strongly calcified, rostrum prominent, beak-like. Eyestalks stout, spiniform ophthalmic scales wide apart, antennal scale large. Chelipeds equal and similar, massive in both sexes, more so in male. Fourth and fifth pair of legs chelate. First two uniramous abdominal appendages in male modified as secondary sexual organs. Female with uniramous first pair of abdominal appendages. Second, third and fourth pair of legs biramous and large, contained in a capacious cup-like brood-pouch formed of a flesh lobe arising from the side of the fifth somite. Uropods symmetrically biramous.

Paramunnopsis hyrtios Henderson, 1888

(Pl. XXIX, 1)

Paramunnopsis hyrtios Henderson 1888, p.99, pl.10, fig.4; Alcock 1905, pp.28-29, pl.2; Ortmann 1937, p.307; Thompson 1943, p.414; Kensley 1990, p.77.

Chelomunnopsis andersoni Alcock 1899, p.115, pl.1; 1901, p.229.

Material: 4 specimens. Off Quilon, Arabian Sea (12.2.1968) 4 males, carapace length 31 to 37 mm. Collected from deep sea trawler catch. Depth of occurrence: 350 m.

Description: Carapace with deep cervical groove, well calcified region anterior to this, cardiac region also with considerable calcification. Rest of the carapace soft and membranous. Rostrum well developed, reaching 1/3 length of eyestalks. Eyestalks 1/2 anterior border of carapace; cornea uniform, 1/5 eyestalks. Antennular peduncle exceeding eyes by their last segment. The flagella 1/3 longer than last antennular segment. Antennal peduncle shorter than antennular peduncle, antennal scale reaching middle of last segment of antennal peduncle, as long as eyestalks without cornea.

Chelipeds massive, equal in size, slightly longer than the entire body in natural position with flexed abdomen. Merus 0.4 length of entire chela, slightly shorter than propodus including finger. The entire dorsal portion and upper half of sides of chela, carpus and merus covered with thick-set, long stiff, golden-yellow bristles arising from coarse squamiform tubercles. Merus with these bristles on lower surface and ischium having them on the border. The opposed fingers with corneous tips. Second leg stout and compressed, not reaching tip of chelipeds, with thick bristles on lower surface of all segments. Carpi, propodi and dactyli with similar bristles on the sides. Dactyli of third legs sabre-shaped with an elongated depression on either side near the proximal end. Fourth and fifth legs flattened and chelate, the former extending beyond the anterior border of carapace by its last three joints, the fixed finger of chela sharply toothed internally.

Abdomen, soft membranous and bag-like with clear segmentation. In male the abdomen more symmetrical with first two abdominal appendages absent, the first pair being specially grooved and directed forward to help in the transference of spermatophores during copulation assisted by the second pair. Telson and the uropods slender, narrow and symmetrical outer rami of uropod ending in a spine. Basipods bearing sharp spines on the inner distal aspect.

The abdomen with a soft fleshy commensure of a colony of Actinozoan polyps forming a sheet or blanket tucked round the telson on one side, being firmly held by the swimmerets of tailfan, the other end being held by the chelae of fourth legs.

Fresh specimen bright red with golden yellow bristles.

Distribution: Zanzibar (Thompson, 1943); Cape Comorin (Alcock, 1905); Waltair, Bay of Bengal (Kemalavent, 1949); Gulf of Martaban (Alcock, 1905); Philippines (Alcock, 1899).

Genus Pasurietes Dana, 1852

Chelipeds equal, subequal or one larger (usually left), with fingers moving horizontally, tips corneous or even calcareous. Fourth pair of pereopods not chelifera, fifth pair chelate.

Males with first two biramous abdominal appendages modified as secondary sexual organs. In females only one pair of uniramous appendages on first abdominal segment. Female with a fleshy foliaceous lobe on left side of fourth somite, protruding to form a sort of brood-pouch.

There are two species of Pasurietes in the present collection.

Key to the species of Pasurietes

1. Antennal flagellum considerably longer than carapace; fingers of chelipeds meeting quite closely throughout their length. .. 2
- Antennal flagellum shorter than carapace. .. .. 3
2. Eyestalks longer than antennular peduncle. .. .. 3
- Eyestalks shorter than antennular peduncle. .. P. salvus
3. Chelipeds not hairy or tomentose. .. .. 4
- Chelipeds densely tomentose. .. P. ciliatus
4. Rostrum long and slender; eyestalks slender .. P. balssophilus
- Rostrum short, broadly triangular; eyestalks stout. .. .. .. P. munidae
5. Fingers in close contact throughout their length when closed; chelipeds not hairy. .. ..

- Fingers leave a gap between their bases when closed; chelipeds beset with long bristles or with matted setae, on the carpus and hand. 7

6. Outer surface of carpus and hand of chelipeds closely covered with flat, scale-like interspersed ciliated tubercles. .. P.longirostris

- Outer surface of carpus and hand of chelipeds granular. P.natalius

7. Antennal flagellum nearly as long as carapace. P.monodon

- Antennal flagellum hardly as long as carapace. .. 8

8. Eyestalks longer than antennular peduncle. .. P.hians

- Eyestalks shorter than antennular peduncle. .. P.investigator

Penaeopsis longirostris Dana 1852

(Pls.V, 1-5; XIV, 1)

Penaeopsis longirostris Dana 1852, p.436-37; Nobili 1903a, p.20; Alcock 1905, pp.36-37, pl.1, fig.5.

Material: 8 specimens: Off Pudumadai (29-12-67) 1 female, carapace length 10.75 mm; 1 male, 15.5 mm; Mandapam (12-1-68), 1 male, 11 mm; 2 females, 7.8, 8.9 (berried); Kanduguli (18-11-67) 1 berried female, 11.2 mm; Mandapam, Palk Bay (13-12-67) 1 male, 16.4 mm; 1 berried female, 10.8 mm. Collected from trawl catches. Depth of occurrence upto 10 meters.

Inhabits shells of Murex larva and Thais species.

Description: Carapace without setae, longer than broad. Rostrum very prominent, slightly deflexed reaching middle of ophthalmic scales. Eyestalks slender, much longer than the anterior border of carapace, antennular and and antennal peduncles. Ophthalmic scales end anteriorly in two spines. Antennal scales long, extending a little beyond middle of last segment of antennal peduncle and with setae; with four antennules on [illegible] flagellum short.

Chelipeds subequal, left longer, Merus with spines on anterior border and tubercles on superior ridge. Carpus with teeth on inner border a few spinules at base of propodus on outer side. Entire upper surface of carpus, propodus and dactylus covered with flat, scale-like tubercles arranged in imbricating manner. The straight cutting edges of chela meet closely throughout the length leaving no space in between. Second and third legs with thick setae on lower margin of ischium, merus, both upper and lower margin of carpus, propodus and dactylus, the last segment having longer and thickly set setae. Propodus with squamiform markings on the inner aspect, to a lesser extend on second leg. In female specimen a fleshy foliaceous lobe in fourth abdominal segment, overlapping the three legs in front forming a brood-pouch.

Colour: Chelipeds and legs purple with bright red cross band near the inner distal border of merus. General body colour creamy white to gray.

Distribution: East Indies (Dana 1852); East Coast of India (Alcock 1905); Singapore (Nobili 1903a).

This species is reported for the first time from Gulf of Mannar and Palk Bay.

*Pseudozius inconstans* Alcock 1905

(pl.V, 6-8)

*Pseudozius inconstans* Alcock 1905, pp.39-40, pl.3, fig.4; Southwell 1906, p.216; Thompson 1943, p.415.

Material: 11 specimens. Mandapam, Gulf of Mannar (25-8-67), 4 males, carapace length 4 to 6.5 mm; 1 female; 6 mm; Rameswaram (28-8-68), 2 males, 6.3, 6.8 mm; 1 female, 5.6 mm; Mandapam, Palk Bay (25-4-67), 2 males,

6.75, 7.8 mm; 1 berried female, 5.2 mm. Collected from the shallow waters. Depth of occurrence: 1-2 m.

Description: Carapace anterior to cervical groove with tufts of setae. The rostrum bluntly pointed, only as prominent as antennal angles, hardly reaching base of ophthalmic scales. Ophthalmic peduncles slender, shorter than front border of carpace and antennular peduncles. Antennal peduncles shorter than eyestalks; antennal acicles not reaching middle of last antennular segments. Antennal flagellum very short, less than half length of carapace.

Chelipeds subequal, the matted setae masking the sculpture. Upper surface of hand and wrist with prominent spines in rows. Fingers when closed with a gap at base, tips corneous; second and third legs with tufts of setae along margins of all segments. Sides of merus and carpus naked; outer distal segment with setae on the inner surface. Claws dark and sharply pointed, anterior end of carpus and propodus of 2nd leg spinose. Eggs relatively large.

Colour: Dirty cream colour, in life. Eyestalks, antennules and antennal flagella violet in colour, fading on prolonged storage in Alcoglycerol formol.

Distribution: Off Calicut, Arabian Sea (Alcock 1905); Gulf of Aden (Thompson 1943); Maldives (Thompson 1943); Ceylon (Southwell 1906).

This is the first report of the species from the Palk Bay.

Genus Glibunarius Dana 1852

Carapace elongate, with distinct, but short rostrum. Eyestalks long and slender antennal flagellum long, non-setose. External maxillipeds

approximated at base. Chelipods similar, equal or subequal, or one may be slightly longer than the other; fingers open and close in a horizontal plane, with corneous and spooned tips. Fourth pair of pereiopods subchelate, fifth pair chelate. Abdominal appendages only on the left side.

This genus is typically tropical, although a few are subtemperate in distribution. There are nine shallow water forms representing this genus in the present collection.

Key to the Indian species of Glibanarius

1. Dactylus of 3rd pair of pereopods decidedly longer than propodus,
- Dactylus of 3rd pair of pereopods never longer than propodus. ..
2. A strong tooth at the proximal end of lower inner border of merus of chelipods. .. .. Gl. infrequentus
- There is no such tooth. .. .. 3
3. Spinules on upper border of palm and fingers outer surface of palm smooth, walking legs with reddish brown longitudinal stripes. Gl. padavensis
- Palm and fingers with more strong spines, palm of chelipods strongly setose, antennal acicle reaching to half way or a little more than half way the penultimate joint of the peduncle. Ambulatory legs with red bordered blue bands. .. .. Gl. longitarsus
4. Acicle reaching to base of last joint of peduncle. Red stripes on legs. Spines on upper border of palm stronger than those of Gl. longitarsus. .. .. Gl. stimpsonus
- Eye stalks short, strong spines on outer surface of palm, legs reddish brown with yellow longitudinal bands. .. Gl. glibanarius
5. Dactylus of 3rd pair of pereopods exactly the same length of propodus. 6
- Dactylus of 3rd legs shorter than propodus. .. 8

6. Outer surface of 3rd left propodus not flattened. Ophthalmic scale widely separated. .. .. Cl. albidigitus

- Spines on the palm, chelipeds, legs and anterior part of carapace red with a profusion of white spots. .. Cl. crucentatus

7. Chelipeds, legs and anterior part of cephalothorax deep red, without spots. .. .. Cl. erythraeus

- Carpus of leg with 3 or 4 tubercles, last two of which are quite large and conspicuous. .. .. Cl. nathi

8. Chelipeds and legs thick and coarsely hirsute, especially the flattened outer surface of propodus of 3rd left leg. Cl. corallinus

- Colour stripes on the legs. No true spines but only tubercles on palm; long hairs on the outer surface of dactylus and propodus of 3rd left legs. .. .. Cl. zebra

9. On palm and fingers spines and long hairs; distal end of propodus of 3rd left leg always of a light colour. .. Cl. mozambicus

- No spines, only tubercles on the palm and fingers and hairs less developed; distal end of propodus of 3rd left leg always with a dark colour. .. .. .. Cl. humilis

## Clibanarius infraspinatus Hilgendorf 1869

(Pl. XIV, 2)

Clibanarius infraspinatus Hilgendorf 1869, p.97; de Man 1887, p.441; 1888, p.257; Ortmann 1892, p.290; Henderson 1893, p.423; Nobili 1903a, p8; 1903c, p.19; Alcock 1905, p.44; Mc Culloch 1913, p.350, fig.52; Sundara Raj 1927, p.130; Buitendijk 1937, p.251; Yap-Chiongco 1938, pp.191-92, pl.2, fig.4; Pike and Serene 1955, pp.77-83, fig.10 A,B,C.

Glibberarius vulgaris de Man 1890, p.112.

Material: 5 specimens. Athankarai estuary: (28-7-1969) 1 female, carapace length 26 mm. Point Calimere: (25-9-1968) 1 male carapace length 31 mm. Kundugal: (15-9-1969) 1 male carapace length 31 mm. Rameswaram: (19-2-1968) 1 female, 23.5 mm; 1 male 18.5 mm. Collected from shallow waters. Depth of occurrence: 1-2 m.

Description: Carapace longer than broad, its breadth 0.78 the length, with tufts of long bristles. Rostrum more prominent than antennal angles, almost reaching base of ophthalmic scales, anterior angles with two spines. Eyestalks long but shorter than anterior breadth of carapace and antennal peduncles. Antennular peduncles longer than ophthalmic peduncles and antennal peduncles. Antennal scale elongated and reaching beyond the base of last joint of antennal peduncle and with six teeth on the inner side in addition to the terminal one. Antennular scale bearing four spinules distally. Antennal flagellum longer than carapace.

Chelipeds of same size, merus with a strong tooth at the near end of the lower inner border and with granules on the outer surface as in Glibberarius glibberarius. Distal superior margin of merus serrated. Carpus with three strong spines in a row on the upper inner margin and a scattered few on the rest of the upper surface. Propodus bearing well developed spines on the inner margin with scattered, less sharp spine and tubercles on the upper and outer surfaces. Tips of fingers spooned corneous and black. Teeth bearing long bristles at their bases. Second and third legs longer than chelopeds. Dactylus longer than propodus, second leg bear a row of five or six spinules on the inner, upper margin of carpus. Propodi and dactyli with long tufts of bristles. Outer surface of propodus of third left leg flatter than in Glibberarius glibberarius.

Colour: In live specimen carapace cream coloured in the anterior region becoming brown posteriorly. Appendages with ground clour of dark ash having orange-yellow longitudinal stripe bordered by read or chocolate lines, on second and third legs only. Dactylus yellow with three red longitudinal lines. Claw dark, with more pale tip of dactylus. Chelipeds also ash coloured with light coloured spine on carpus and chela. Tip of fingers black; lower inner surface of the legs light yellowish or cream. Abdomen dark on the dorsal side.

Clibanarius infrarainatus is found to occupy shells of the gastropods Tonna dolium, Turbo spp. which have very wide mouths.

Distribution: Red Sea (Ortmann 1892; Nobili 1903); northwest coast of India (Southwell 1909); East coast of Indian (Henderson 1893; Reddi 1955; Sundara Raj 1927); Mergui and Tavoy (de Man 1888; Alcock 1905); Singapore (Hilgendorf 1869; Nobili 1903c); Philippines (Yap-Chiongco 1938); Viet Nam (Fize and Serene 1955); Taiwan (Lee 1969); Borneo (Nobili 1903a); Australia (Ortmann 1892; Mc Culloch 1913).

The specie is reported from the Palk Bay for the first time.

Clibanarius padavensis de Man 1888

(Fig.V, 15-17; XIV, 3)

Clibanarius padavensis de Man 1888, p.242, pl.16, fig.1; Alcock 1905, p.44-46, pl.4, fig.2; Southwell 1906, p.215; Henderson, 1915, p.25; Kemp 1915, p.250; Sundara Raj 1927, p.130; Panikkar and Aiyar 1937, p.296; Gravely 1941, p.77; Buitendijk 1947, p.280; Barnard 1950, p.433.

Material: Athankarai estuary: Several specimens ranging in carapace length 5 to 26 mm, in females (including many with egg masses) and from 4.8 to 26.5 mm in males. Collected on 26-6-67, 27-7-67, 30-8-67 and 26-2-68 from shallow waters of the estuary. Depth of occurrence; 1 - 2 m.

Inhabits shells of Turritella attenuata, Thais bufo, Natica didyma, Murex tarva, and Babylonia spirata, Hemifusus spp., and Oliva sp.

Description: Carapace longer than broad. Rostrum well formed, reaching base of ophthalmic scales and beyond the level of the antennal angles of the carapace. Eyestalks longer than anterior border of carapace almost as long as antennular peduncle. Cornea about one-eighth of eyestalk. Ophthalmic scales situated close to one another, with spinose outer margin. Antennal sciole with serrated margins, almost reaching base of terminal joint of antennal peduncle. Flagellum twice as long as carapace.

Chelipeds of equal size, one-third as long as carapace. Two spinules at the distal end on lower outer aspect of merus, lower inner margin being serrulate. Carpus with a strong spine on dorsal inner aspect, distally. Fingers with dorsal spines in rows. Setae long and sparsely uniform.

The percentage occurrence of berried females specimens collected during the different months indicate that the peak breeding season is in February after the northeast monsoon rains.

Colour: In live specimens the colour is yellow with straight red longitudinal lines in two or three series on second to fifth legs. Eyestalk with one dorsal red band and another on its inner aspect. Chelipeds with less distinct and interrupted bands of same colour. Carapace yellow. Antennular and antennal peduncles with red bands, flagella yellow.

Distribution: East coast of India (Alcock, 1905; Henderson, 1915; Kemp, 1915; Sundara Raj, 1927; Panikkar and Aiyar, 1937; Gravely, 1941); Gulf of Mannar, Ceylon (Southwell, 1906); Mergui Archipelago (de Man, 1888).

Sh. pulvinosis is reported from the Palk Bay for the first time.

Thiosoma lamellatum (de Haan, 1849)

(Fig.V, 9-11; XIV, 4)

Pseudo lamellatum de Haan, p.211, pl.50, fig.3.

Pseudo (Thiosoma) lamellatum Hilgendorf 1869, pp.96-97.

Thiosoma lamellatum Dana 1852, p.464; Stimpson 1858, p.247; Heller 1865, p.90; Hilgendorf 1878, pp.821-822; de Man 1888, p.441; Ortmann 1894, p.51; Nobili 1903b, p.15; 1903c, p.20; Fize and Serene 1955, pp.85-90, fig.11, A,B,C., pl.3, 1,7,10,13. (Synonymy).

Thiosoma lamellatum de Man 1902, p.741; Lenz 1905, p.577; Nobili 1906, p.116; Stimpson 1907, p.209; Henderson 1915, p.25; Kemp 1915, p.250; Stebbing 1917, p.82; Whitendijk 1937, p.255; Chace 1942, p.186; Barnard 1950, p.434.

Material: Several specimens. Moondakurai Estuary, Quilon, (23-12-1967) 2 males, carapace length, 16, 22 mm; 2 females, 15, 24 mm; Pulli Island (22-2-1968) 7 specimens, 11 - 21 mm; Mandapam, (14-2-1967) 35 males, 8 - 18.5 mm; females, 8.5 - 17 mm (4 berried); (28-7-1967) 7 males, 14 - 22 mm; 2 females, 9.5, 15 mm; Krusadai Island, (20-2-1968), 2 males, 14, 17 mm; 2 females, 12, 13 mm; Rameswaram, (26-8-1968) 15 males, 9.5 - 25 mm; 5 females, 12 - 25.5 mm. Depth of occurrence upto 1 m.

Inhabits shells of wide mouthed gastropods such as Trochus sp. Tibia curta, Murex spiralis, Xancus cornus, Turritella acutangula and Strombus sp.

Description: Carapace well developed, reaching level of base of ophthalmic scales. Eyestalks without colour bands, as long as antennular peduncle, equal to anterior breadth of carapace. Ophthalmic scale small, with pointed tips. Antennal scales reaching a little short of last segment of antennal peduncle, with serrated inner margins.

Cheliped equal, with spooned fingers ending in dark corneous tips; uniformly provided with long setae. Palm and wrist with dark-tipped spines in one or two rows on fingers and irregularly arranged on palm. Merus with a spinule on outer distal aspect, carpus with a well developed spine dorsally towards distal end, internally. Dactylus of third leg longer than propodus. Ambulatory legs with a blue band bordered with red.

Colour: Bluish green body with characteristic blue and red band on the ambulatory legs.

Distribution: East coast of Africa (Hilgendorf, 1869; Stebbing, 1917; Chace, 1942; Barnard, 1950); Indian Ocean (Lanchester, 1902); East coast of India (Alcock, 1905; Henderson, 1915; Kemp, 1915; Nobili, 1905b); Nicobar (Heller, 1865); Singapore (Nobili, 1905a); Viet Nam (Fize and Serene, 1955); China (Stimpson, 1859); Japan (de Haan, 1849).

Clibanarius strigatus Dana 1852

(Pl. XIV, 5)

Clibanarius strigatus Dana 1852, p.463; Stimpson 1859, p.247; 1907, p.210; Heller 1865, p.89; de Man 1888, p.241; 1902, p.741; Nobili 1905a, p.19;

1906, p.116; Mc Culloch 1913, p.348; Kemp & Sewell 1937, p.258; Kemp & Sewell 1937; p.501; Yap-Chiongco 1938, p.192, pl.1, fig.1; Barnard 1950, p.434; Forest 1953, p.448; Pisa and Serene 1955, pp.97-105, fig.13, A,B,C; pl.3, 4 (Synonymy).

Material: 4 specimens. Minicoy Island (20-5-70), two males, carapace length 16.5, 17.75 mm; 2 females, 13.5, 14 mm (berried). Collected from shallow waters. Depth of occurrence: 1 - 2 m.

Description: Rostrum short, not reaching base of ophthalmic scales. Antennule shorter than length of eye; eyestalks equal to anterior breadth of carapace. Antennular flagellum 1.6 times length of carapace. Antennal scale reaching only to base of last joint of antennular peduncle. Eye without longitudinal brown bands as in Cl.pedavensis. Red stripes on legs.

Colour: In fresh specimens carapace red with brown and white patches, anteromedian portion with a brown blotch. Antennular and antennal peduncles violet in colour. Cheliped with white spines with dark tips. Legs having reddish brown cross bars interspersed with white spots. Claws of legs dark in colour. Tergal plates on abdomen with white and reddish brown spots. Setae also reddish brown with white tips.

Distribution: Red Sea (Bouvier 1890-91; Nobili 1906); Arabian Sea (Alcock 1905); Seychelles (Richters 1880); South Africa (Barnard 1950); Ceylon (Alcock 1905); Mergui Archipelago (Alcock 1905); Penang (Lanchester 1902); Nicobar (Heller 1865); Philippines (Kemp & Sewell 1937; Yap-Chiongco 1938); Viet Nam (Pisa and Serene 1955); Japan (Ortmann 1892); China (Stimpson 1859, 1907); Pacific Ocean (Dana 1852; Ortmann 1892; Forest 1953).

This is the first report of this species from the Laccadives.

Clibanarius albidorsus (Herbst, 1791)

(Pl. XXV, 6);

Cancer albidorsus Herbst, 1791, p.20, pl.23, fig.1.

Pagurus albidorsus Latreille, 1803, p.167; Milne Edwards, 1836, p.276; 1837, p.227; 1848, p.62.

Clibanarius albidorsus Hilgendorf, 1878, p.620; Henderson, 1893, p.423; Nathbun, 1900, p.306; Alcock, 1905, p.43; Estampador, 1937, p.501; Yap-Chiongco, 1938, p.190; Barnard, 1950, p.433.

Material: 12 specimens. Cuddalore: (9-11-68) 4 males, carapace length 19.25 to 36 mm; 2 females, 19.5 and 21 mm; Kakinada: (8-4-69) 4 males, 22 to 33 mm; 2 females, 31.5, 36 mm. Collected from trawl catches. Depth of occurrence: 25 m.

Description: Carapace longer than broad, its greatest breadth 0.8 its length along themiddle line. Rostrum small just reaching base of ophthalmic scales, a little projecting beyond antennal angles of carapace. Ophthalmic peduncles slender, as long as anterior border of carapace and antennal peduncle. Antennular peduncle surpassing eye stalk by less than half length of last segment of antennular peduncle, all being beset with tufts of long yellow bristles. Free ends of ophthalmic scales spinose. Antennal acicle with spines and setae. Flagellum longer than carapace.

Chelipeds equal, much more massive than other legs, merus with some tubercles on its outer surface, inner lower margin toothed and upper surface of carpus and chela spinous. Inner surface of palm with tubercles. Fingers spooned, tips black and corneous. Tufts of bristles arising from the bases of spines. Second and third legs longer than chelae, without tubercles on superior surface, beset with long bristles, more so on dactylus. Carpus of second leg with five or six spinules on upper border.

The specimens agree with Alcock's description in most of the details.

Colour: Reddish brown with yellow longitudinal lines on eye stalks, second and third legs. Branchial region of carapace with yellow lines and dots.

Distribution: Southeast coast of Africa (Hilgendorf, 1878); Bay of Bengal (Alcock, 1905); Philippines (Rustompadar, 1937; Yap-Chiongco, 1938).

## Clibanarius viridinus de Man 1888

(Pls.VII, 1-3; XV, 1)

Clibanarius viridinus de Man 1888, p.252; Henderson 1893, p.424; Alcock, 1905, p.48, pl.4, fig.3 (Synonymy); Sundara Raj 1927, p.131; Reddi 1955, p.562; Pise and Serene 1955, p.114-118, fig.16 - A, B, B1, C (Synonymy).

Material: 20 specimens. Kilakkarai: (30-6-69) 1 male, carapace length, 14.25 mm; Vedalai: (24-6-67) 1 male, 24.5 mm; 1 berried female, 21 mm; Krusadai Island: (12-10-69) 1 male, 16.8 mm; 1 female, 18.75 mm; Thonitharai (21-8-67) 1 male, 20.75 mm; Mandapam (14-2-67) 1 female, 17 mm; Mandapam (4-8-67) 2 males, 14 and 10 mm; Kacha Tivu (25-3-67) 1 female, 18.75 mm; Lawson's Bay, Valtair (28-10-67) 3 males, 11 to 13.5 mm; 3 females, 11.5 to 12.75 mm. Collected from shallow intertidal zone. Depth of occurrence 1 - 2 m.

Inhabits shells of Turbinella spp., Murex virgineus and Turbo spp.

Colour: In life carapace white or light grey; eyestalks, antennules, antennae, chelipeds and legs deep orange red with black tipped fingers of chelipeds and dactyli.

Description: Eyestalks shorter than antennular peduncles; ophthalmic scale narrow, pointed at tip and close together. Numerous tufts of setae on gastric region and behind cervical groove. Antennal acicle reaching about one-third last antennal segment. A few conical spinules with blunt tips on hand and wrist. Dactylus of third pair of legs of same length as propodite. Propodite with flattened outer surface; but devoid of superior external carina.

Colour: In life carapace white or light grey; eyestalks, antennules, antennae, cheliped and legs deep [illegible] red with black tipped fingers of chelipeds and dactyli.

Distribution: East coast of India (Alcock 1905; Sundara Raj 1927; Reddi 1955); Mergui Archipelago (de Man 1888; Alcock 1905); Viet Nam (Fize and Serene 1955).

*Thiberonius serellinus* (Milne Edwards 1848)

(Pl. VI, 1 - 5)

*Pagurus serellinus* Milne Edwards 1848, p.63.

*Thiberonius serellinus* Dana 1852, p.460; de Man 1888, p.447; Alcock 1905, p.48, pl.5, fig.1; Fize and Serene 1955, pp.132-138, fig.20, A, B, B1, C (Synonymy).

*Thiberonius granulatus* Grant and Mc Culloch, 1906, p.53; Whitelegge 1897, p.292.

*Thiberonius globosimanus* Stimpson, 1907, p.210.

Material: Aberdeen Bay, Andaman Island (25-1-1965) 1 male, carapace length 11 mm. Collected from the littoral zone. Depth of occurrence 1 - 3 m.

Description: Carapace much elongated, 1.9 times as long as broad; rostrum pointed, reaching bases of ophthalmic scales, more prominent than antennal angles. Ophthalmic pedunculos long 1.25 times as long as the anterior border of carapace. Ophthalmic scales lyred at the bases and narrow distally bearing 1-3 spinules at the tips. Antennular pedunculos shorter than eyestalk and a little longer than antennal pedunculos. Antennal acicle elongated, reaching beyond the base of the last antennal segment flagella shorter than carapace in length.

Chelae subequal, merus almost oval and flat on the outer side, with two spinule on the lower outer side distally. Carpus, propodus and dactylus bearing pointed spines with dark tip and tufts of bristles and their bases, on the superior surfaces. Fingers with similar spines on the upper lateral aspects also. Lower surface of the fingers having tubercles with and without tufts of bristles. Long stiff bristles on the upper surface of chela, carpus and merus. Dactyli of third legs shorter than the propodi; second and third legs longer than cheliped, second extending beyond tip of third leg. Propodus of third leg flat with thick and coarse bristles, claws sharp and black.

Colour: Reddish brown with dark brown bristles. Eyestalks and antennal flagella yellowish in preserved specimens.

Distribution: Andaman and Nicobar Islands (Heller 1865; Alcock 1905); Malay Archipelago (Lanchester 1902); East Indies (H.Milne Edwards 1848; de Man 1888); Philippine (Yap-Chiongco 1938); Australia (Boone 1935); Pacific Ocean (Dana 1852; Stimpson 1907; Edmondson 1925).

## Gilbernesius gebra Dana 1852

(Pl. V, 18 - 20)

Gilbernesius gebra Dana 1852, p.465; Stimpson 1859, p.235; Borradaile 1890, p.463; Nobili 1907, p.367; Alcock 1905, p.159; Edmondson 1933, p.226; 1946, p.265; Rathbun 1937, p.264; Eddy, 1966, pp.545-546.

Material: Hyunsadai Island (12-18-69) 3 females, carapace length 5.75 to 8.5 mm (one berried). Collected from shallow water. Depth of occurrence 1 - 2 m.

Description: Carapace longer than broad; rostrum pointed reaching almost the bases of ophthalmic scales. Antennal angles of carapace not prominent. Eyestalks a little longer than anterior border of carapace, antennular and antennal peduncles. Ophthalmic scales broader at the base with sharp teeth on the distal end, innermost one on either side being largest. Antennal scale elongated, reaching beyond the base of last segment of antennal peduncle and bearing teeth on either side. Antennal flagellum longer than carapace.

Chelipeds subequal; merus with a few tubercles on the outer surface; carpus, propodus and dactylus with sharp teeth and tubercles on the upper surface. Fingertips spooned, corneous and black, with uniformly arranged long setae. Second and third legs longer than chelipeds, ending in sharp black claws. Carpus with strong spine on the upper far end and with setae on the sides.

Colour: Chelae and legs yellow. Second and third legs with longitudinal reddish brown bands, an upper and a lower band, on carpus and propodus, single band near the ventral side on merus and dactylus.

Distribution: West coast of India (Reddy 1966); East Indies (Kemp Buitendijk 1937); Pacific Ocean (Dana 1852; Borradaile 1898; Nobili 1907; Edmondson 1933, 1946).

This is the first record of this species from east coast of India.

Clibanarius zanzibaricus (de Man 1888)

(Pl.V, 12-14)

Clibanarius zebra var. zanzibaricus, de Man 1888, p.247; Lenchester 1902, p.365; Alcock 1905, p.47, pl.4, fig.5; Southwell 1906, p.215; Balss 1916, p.9; Buitendijk 1937, p.265; Pike and Serene 1955, pp.145-150, fig.22, A, B, C.

Clibanarius zanzibaricus Forest 1953, p.438, 445, fig.7; Deshmukh 1964, p.32.

Material: 28 specimens. Pamban (25-4-1967) 4 males, carapace length, 22 - 24 mm; 2 females, 19.5 - 21 mm; Krusadai Island (22-2-1968) 5 males, 9-14 mm; 8 females, 6-7 mm (3 berried); Mandapam, Palk Bay (10-6-69) 8 specimens (juveniles); Kasba Tivu (15-3-1969) 1 berried female, 6.5 mm. Collected from near the low water level. Depth of occurrence 1 - 2 m.

Description: Length of carapace, in the midderal line 1.27 times the greatest width. Rostrum surpassing the antennal angles unlike Alcock's material, reaching beyond the base of the ophthalmic scales. Eyestalks as long as the anterior border of carapace; slightly longer than the antennular peduncle. Ophthalmic scales broad, approximated and with spinous anterior ends.

Chelipods subequal, as long as carapace. Inner lower edge of merus serrate. Distalmost segments of chelipods with strong conical spines interspersed with long setae, with a gap near the basal portion of fingers. Second and third legs reaching beyond chelipods by the length of dactylus and one-third propodus; smooth with less densely arranged setae. Outer surface of left propodus remarkably flattened with upper margin well defined; dactyli of both legs compressed.

Colour: Fresh specimens with carapace and legs grey, tips of propodi of second and third legs being lighter in shade. Dactyli pale with longitudinal band of same colour as rest of the body.

The specimen from Kasba Tivu was grey with white patches, even after preserving in oleo-glycero-formol for two years while those from Krusadai Island turned yellow to orange in colour on prolonged preservation in the same preservative.

Distribution: Red Sea (Balss 1916); Western Indian Ocean (Bouvier 1915; Forest 1955; Barnard 1964); Gulf of Manaar, Ceylon (Southwell 1906); Mergui Archipelago (de Man 1888; Alcock 1905); Malaysia (Lanchester 1902); East Indies (Rathbun 1937); Viet Nam (Fize and Serene 1955).

This is the first report of the species from Kasba Tivu, Palk Bay.

Genus Parthenope Fabricius 1793

Rostrum absent. Eyestalks stout, ophthalmic somite exposed; ophthalmic acicles large, widely separated.

Chelipods usually unequal and dissimilar, left much longer. Tips of fingers opposed and corneous, especially smaller; chelipod move in obliquely vertical plane.

The genus is represented by five species in the collections.

Key to the species of Parthenope

1. Eyes talks reach very nearly to or even surpass the end of antennular peduncles; eyes never occupy as much as 1/3 the terminal joint of eyestalks. ..
- Eyestalks coarse and broad; do not nearly reach to the end of antennular peduncle; eyes occupy a third or more of terminal joint of eyestalks. .. .. 8
2. Greatest breadth of carapace across of the branchial region less than length of carapace in the middle line.
- Greatest breadth equal to length of carapace; left cheliped moderately larger than the right; outer surface of last two joints of third left leg transversely striated. .. P. gibbosa
3. Left cheliped vastly larger and longer than right. .. 4
- Left cheliped decidedly larger but not much larger than right; joints of distal half of the antennal flagellum strongly gibbous. .. .. P. crassa
4. The whole outer surface of left hand spinose. .. 5
- The outer surface of left hand granulose, except for a few spinules along its upper margin. .. P. fabiosoma
5. Outer surface of propodite of third left leg spinose. .. 6
- Outer surface of propodus and dactylus of third left leg with regular transverse squamiform markings. .. P. antilla
6. Chelipeds and legs very hairy; hand of left cheliped not inclined inwards. .. .. 7
- Chelipeds and legs bare or sparsely setose, hand of left cheliped strongly inclined inwards. .. P. west-woodi
7. Carapace and legs copiously ocellated. .. P. maculata

). Left cheliped vastly longer than right. .. 9

. Both chelipeds are of same size and form. P. hanai

). Outer surface of left hand closely covered with imbricating scale-like tubercles. .. P. imbricatus

. No squamiform tubercles. .. .. 10

). Inner border of upper surface of dactylus of left cheliped sharply crest-like. .. P. deformis

. Upper surface of dactylus of left cheliped with longitudinal rows of granules only. .. .. 11

1. Outer edge of upper surface of propodus of third leg well defined, subcristiform. .. P. variegatus

. Outer edge of upper surface of propodus of third leg hardly defined. .. .. 12

12. Upper part of outer surface of left hand with two or three raised longitudinal rows of granules or small tubercles, lower part smooth. .. P. serratus

. Whole outer surface of left hand uniformly granulose. P. dentatus

## Pardosoma setifer (Milne Edwards 1836)

(Pl. XV, 2)

Pagurus setifer Milne Edwards 1836, p.274; 1837, p.225; Henderson 1893, p.180; Alcock 1905, p.85, pl.8, fig.3; Southwell 1906, p.214; Lenz 1910, pp.563-564; Turne 1913, p.379; Balss 1921, p.19; Sundara Raj 1927, p.131; Barnard 1950, pp.486-487, fig.79; Pino and Serene 1955, pp.182-189 (Synonymy).

Material: 7 specimens. Kilakkarai (21-12-67); 1 male, carapace length 32.5 mm; Off Pudumadam (15-2-69), 1 female, 26 mm; Mandapam, Palk Bay

(12-3-67), 1 male, 30 mm; Kalimnda (8-4-68) 2 males, 16, 8 mm; 2 females, 8.6, 10 mm. Collected from tunnel catches. Depth of occurrence 8 - 12 m.

Description: Eyestalks as long as anterior border of carapace slightly longer than antennal peduncles. Antennular peduncles longer than eyestalks and antennal peduncles. Ophthalmic scales wide apart. Antennal scales extending beyond the base of last segment of antennal peduncle. On the distal half of antennal flagella the anterolateral angles of the joints being produced.

Left cheliped massive with tubercles and black-tipped thorn-like spines. A longitudinal ridge along the lower margin of left chela and a row of strong spines along the inner, upper margin. Strong spine on the inner upper border also. Spines on the cheliped surrounded by wreaths of stiff, short, setae around the bases. The last two segments of third left leg broadened and have rows of transverse spinose carina, either side of the carina being tesselated by a series of deep and regular transverse grooves.

Colour: Fresh specimens brightly coloured. The chelipeds bright brick-red while the second and third legs having cross bands of same colour. Setae dark red with light tips. Antennules and antennae, eyestalks and other parts of the body yellowish.

Distribution: South Africa (Barnard 1950); Malabar Coast (Alcock 1905); Gulf of Mannar (Henderson 1888); Ceylon coast (Muller 1886; Alcock 1905; Lenz 1910); East coast of India (Alcock 1905); Bay of Bengal (Henderson 1888); Gulf of Martaban (Henderson 1888); Viet Nam (Pino and Serene 1955); Hong Kong (Alcock 1905).

## Penaeus monodon (Fabricius 1804)

(Pl. XV, 3)

Penaeus monodon Fabricius 1804, p.28, pl.2, fig.1.

Penaeus monodon Olivier 1911, p.639; Stebbing 1908, p.21; 1910, p.350; 1917, p.21; Barnard 1950, p.425, fig.79a; Forest 1953, p.559; Pike and Serene, 1955, pp.160-166, pl.4A, fig.24 A,B,C (Synonymy).

Penaeus punctulatus Olivier 1811, p.641; Milne Edwards 1836, p..222; 1948, p.61; Alcock 1905, pp.81-82, pl.8, fig.1; Sundara Raj 1927, p.131; Redd 1955, p.661.

Material: 20 specimens. Kavarathy Island (21-1-68) 1 male, carapace length 13.8 mm and 1 female 14 mm; Minicoy Island (15-2-70) 1 female, 30.3 mm; Kilakkarai (27-4-67) 1 male, 21.75 mm; Off Pudumadam, Gulf of Mannar (7-12-69) 1 male 37 mm; Nare Island (27-4-68) 1 female, 18 mm; Corbyn's Cove, Port Blair (9-5-68) 1 male, 19.9 mm; 1 female, 32 mm; Nancowry Island, Nicobar (12-5-69) 1 female, 25.5 mm. Collected from the littoral [illegible] and trawl catches. Depth of occurrence: 2 - 10 m.

Description: Carapace elongated, 1.5 times as long as broad, with tufts of bristles near the anterolateral margin. Rostrum not well defined, antennal angles prominent and bluntly pointed. Eyestalks moderately elongated, equal in length to antennular peduncle and the anterior border of carapace, its length 4.8 times the cornea. Ophthalmic scales well developed, separated, narrower at the tips and bearing 3 spinules. Antennal scale straight, pointed, reaching beyond base of last antennal segment,

with two spinules on the inner margin. Two stout, white spines are situated posterior to the base of the setules.

Chelipeds dissimilar, left one vastly larger and massive second and third legs with thickly beset tufts of red bristles on the last three joints, especially on the outer surfaces. Second and third legs of right side longer reaching beyond the chelipeds. Merus of left cheliped with large backwardly directed teeth at the lower inner side, proximally, two spinules at the distal, outer end and anterior margin; carpus with four strong spines on the upper inner border with additional spines on the superior surface. Propodus and dactylus with stout and thin black tipped spines on the upper surface.

P. messinae is the largest Indian species common in the Gulf of Mannar exhibiting preference to light gastropod shells of Turbo dalium which are quite common in the locality. One male specimen measuring 37 mm in carapace length was kept in the aquarium for over 9 months on a diet of clam flesh.

Colour: Live specimens blood-red in colour with white spots scattered all over the carapace, legs and abdominal terga. Setae also reddish while spines may be white, brown or red.

Distribution: Red Sea (Hilgendorf 1878; Nobili 1905); Laccadive Archipelago (Alcock 1905; 1906); Western Indian Ocean (Hilgendorf 1869; Richters 1880; Ortmann 1892; Stebbing 1908; 1910; 1917; Barnard 1950); Ceylon (Miller 1886; Southwell 1906); east coast of India (Sundara Raj 1927; Reddi 1935); Mergui Archipelago (de Man 1888a; Alcock 1905); Andamans (Alcock 1905); Nicobar (Heller 1865); East Indies (Stimpson 1858; Miers 1880; de Man 1888b; 1902; Balss 1937); Philippines (Yap-Chiongco 1938); Viet Nam (Vine and Serene 1955); Taiwan (Lee 1969); China (Dana 1852); Australia (Haswell 1882;

Grant and MacCulloch 1906; Mc Neill 1926; Kale 1927; Stephenson et.al.1930); Pacific Ocean (Keller 1865; Bouvredaile 1898; 1900; Rathbun 1905; Stimpson 1907).

Pseudione henni (Miers 1884)

(Pl. XV, 4)

Pseudione henni Miers 1884, p.185, 264; Henderson 1893, p.419; Alcock 1902, p.852; 1905, p.95, pl.8, fig.4; Lanchester 1903, p.364; Kales 1913, p.49; Sundara Raj 1927, p.131; Nobili 1955, p.562; Thompson 1943, p.416.

Pseudione henni Fize and Serene 1955, pp.214-220, fig.34 A,B,C pl.4 (Synonymy).

Pseudione similimana Henderson 1888, p.59, pl.6, fig.6; Estampador 1937, p.503.

Material: 17 specimens. Manapam, Gulf of Mannar (11-11-69), 1 berried female carapace length 23 mm; Kakinada (8-4-68), 8 males, 10.3 to 30 mm; 8 females, 15 to 25.6 mm (6 berried). Collected from trawl catches. Depth of occurrence: 10 - 25 m.

Inhabit shells of Nassa dolium, Murex sp.

Description: Carapace elongate, its greatest breadth across branchial region about 2/3 its length. Rostalim much broadened distally. Cornea reniform. Antennular peduncle longer than antennal peduncle. Antennal peduncle almost as long as anterior border of carapace. Ophthalmic acicles wide apart. Antennal acicle extend well beyond base of the last segment of antennular peduncle.

Chelipod equal and similar, fingers moving in an oblique plane. Finger tips corneous and dark. Merus with a few spines on inner distal end. Carpus and palm haveing a row of strong spines on the inner upper margins with more rows outer to this. Setae long and uniformly distributed on the chela and carpus; merus bearing setae only on the margins. Carpi, propodi and dactyli of second and third legs with spines on antero-dorsal surface.

Colour: Carapace and legs whitish except the fingers and distal part of palm of chelae which are bright brick red in colour.

Distribution: East Coast of India (Henderson 1893; Alcock 1905); Gulf of Martaban (Henderson 1893; Alcock 1905); Malaya Peninsula (Lanchester 1902); Viet Nam (Fize and Serene 1955); Celebes (Henderson 1888); Arafura Sea (Miers 1884); Type locality Gulf of Cann (Thompson 1943).

Parthenope deformis (Milne Edwards 1836)
(Pl.IV, 5)

Parthenope deformis Milne Edwards, 1836, p.272; 1837, p.222; 1840, p.60; Randall, 1840, p.133; Dana 1852, p.449; Stimpson 1859, p.246; 1907, p.204; Hilgendorf 1878, p.186; 1878, p.818; de Man 1887, p.435; 1888, p.225; 1902, p.740; Henderson 1888, p.57; 1893, p.480; Alcock 1902, p.852; 1905, p.89-90, pl.9, fig.4; Fize and Serene 1955, pp.199-207, fig.31, A,B,C, fig.33, E, F. pl.6 (Synonymy);

Parthenope deformis Mc Neill 1926, p.303; Buitendijk, 1937, p.275; Deshmane 1964, p.33.

Material: 8 specimens. Andaman and Nicobar Islands (14-5-69), 4 males, carapace length, 19 - 28.4 mm; 4 females, 18 - 22 mm (2 berried). Collected from trawl catches. Depth of occurrence: 6 - 12 m.

Descriptions: Carapace depressed setose only on the margins. Eyestalks short and broadened distally; shorter than antennal peduncle, extending about middle of last segment of antennular peduncle. Antennal scales reach well beyond the base of terminal antennal joint. Ophthalmic scales roughly triangular and placed wide a part.

Left cheliped vastly larger. Chela longer than broad. Merus with blunt spines on outer margin and a sharp spine on the distal inner aspect. Carpus with many spines towards the inner side and superior surface, outer lower aspects smooth. Palm with a row of strong spines on the inner upper surface with a few more outer rows of smaller and less defined spines. Lower margin of chela with a row of tubercles. Dactylus with an upstanding crenulated crest along the inner edge of the upper surface of dactylus. Upper outer surface of propodus and dactylus raised into finely crenulated overhanging crest. Outer surface of dactylus concave.

Male specimens have openings corresponding to female genital pores on the base of the third pair of legs.

Colours: Preserved specimens biscuit yellow with reddish tinge on the legs; eyestalks and carapace.

Distributions: Red Sea (Nobili 1906); Western Indian Ocean (Milne Edwards, 1836, 1837, 1848; Lenz 1905; Ortmann 1892; Richters 1880; Bouvier 1915; Cuvier 1920); South Africa (Stebbing 1917; Barnard 1950); Maldives and Laccadives (Barradaile 1898); Ceylon (Haller, 1886); Tuticorin, Gulf of Mannar (Henderson 1888); Mergui Archipelago (de Man 1887; Alcock 1905); Andamans (Alcock 1905); Philippines (White 1848; Miers 1880; Yap-Chiongco 1936); East Indies (de Man 1902; Buitendijk 1937; Hilgendorf 1878); Japan (Stimpson 1859); Australia (White 1848; Miers 1875; Grant and Mc Culloch

; Mc Neill 1926; Boone,1935; Stephenson,et.al. 1958); Pacific Ocean (Randall 1840; Dana,1852; Milne Edwards,1852; Heller,1865; Henderson,1888; Haswell 1898; Nobili,1907; Boone,1935).

Parthenope agassizi (de Haan,1849)

Parthenope agassizi de Haan,1849, p.208; Alcock,1905, p.90-91, pl.9, fig.5 (Synonymy); Southwell,1906, pp.228 214-215; Stimpson,1907, p.204; Terao,1915, p.376; Estampador, 1937, p.502; Yap-Chiongco,1938, p.197; Thompson, 1943, p.146; Edmondson,1946, p.263; Barnard,1950, p.430.

Parthenope hanni Lenzie 1926, p.158.

Parthenope agassizi Edmondson 1926, p.24; Dechance 1964, p.33.

Parthenope hanni Rathbun 1903, p.34; Buitendijk 1937b, p.275.

Material: 1 specimen off Mandapam, Gulf of Mannar (26-8-69), 1 male, carapace length, 15.2 mm. Collected from deep sea trawls. Depth of occurrence: 200 m.

Description: Closely resembling P. deformis, but differing from it in the absence of canina on the upper outer border of propodus and the presence of only a longitudinal row of granules on the upper surface of dactylus of left cheliped. Chaped with a few rows of spines and granules on the upper inner side of the palm and a few granules in a row near the distal end of the palm on the outer lower aspect. Rest of the palm smooth. Carpus having a few pointed spines on the innerupper surface with a few more on the superior surface. Outer lower part of carpus devoid of spines and granules. Merus bearing sharp spine on the superior inner surface

Outer surface of carpus of the third leg smooth, without crest. A longitudinal concavity on the outer side of dactylus of the third leg. No trace of hermaphroditism as in P. deformis.

Colour: Carapace and legs yellowish pink with brighter pink marks on the anterior part of carapace, segments of legs eyestalks and antennal and antennular peduncles. Setae golden yellow.

Distribution: Gulf of Aden (Thompson 1943); Western Indian Ocean (Barnard 1950; Deshmukh 1964); Maldives (Thompson 1943); Gulf of Mannar, Ceylon (Alcock 1905; Southwell 1906); Andamans (Alcock 1905); East Indies (Whitendisk 1937); Philippines (Estampador 1937; Yap-Chiongco 1938); Japan (Terao 1913); Pacific Ocean (Dana 1852; Borradaile 1900; Rathbun 1905; Stimpson 1907; Edmondson 1926, 1946).

## Genus Pinnaxes Dana 1852

Carapace elongate well calcified in front of the cervical groove and in the neighbourhood of cardiac region. Rostrum replaced by a moveable rostriform process of the ophthalmic somite.

Eyestalks moderately slender with large ophthalmic scales, separated by the 'rostrum'.

Cheliped dissimilar, unequal, left being greatly larger, fingers move in an obliquely vertical direction, finger tips acuminate and calcareous.

Fourth pair of legs subchelate, fifth chelate. Four pleopods on left side only, on somites 2-5, first three being biramous in females; in males all being uniramous. Telson and uropods more developed on the left side than the right.

This characteristic Indo-Pacific genus is represented in the present collection by 6 species.

Key to the species of Diagonus

1. The rostrum in the form of a narrow lamina, with the free edge spinose, at any rate distally. .. 2
- Rostrum slender, simple (non-serrated) .. 6
2. Carapace longer than broad; left hand when fully extended not inclined inwards. .. .. 3
- Carapace broader than long; left hand strongly inclined inwards even when fully extended. D. miles
3. Antennal scale bifurcate, inner (shorter) branch reaches the base of terminal joint of peduncle; outer surface of left hand beset with with conical tubercles, each with a wreath of short stiff radiating setae. D. mauritiensis
- Antennal scale bifurcate, inner branch reaches half-way along the penultimate joint of peduncle. .. 4
4. Outer (longer) branch of antennal scale barely reaches the base of terminal joint of peduncle; outer surface of left hand beset with claw-shaped spines. D. diagonus
- Outer branch of scale reaches well beyond base of last joint of peduncle; outer surface of left hand closely and finely granulate. .. D. custos
- Antennal scale obscurely bifurcate, outer branch not reaching base of terminal joint of peduncle; outer surface of left hand closely and finely granulose. .. 5
5. Left hand nearly oval, palm higher than long D. affinis

Left hand as long as high, lower part of outer surface flattened. P. planimanus

Left hand oblong, palm longer than high. P. violascens

Eyestalks not so long as anterior border of carapace or as the antennal peduncle. ..

Eyestalks considerably longer than anterior border of carapace or than antennal peduncle; left cheliped hairy. .. P. cardinesi

Fixed finger of left chelipeds deflexed. ..

Fixed finger of left cheliped not deflexed; a single longitudinal row of spinules on upper part of outer surface of left palm. ..

Eyestalks reach nearly the middle third of terminal joint of antennular peduncle; wrist and hand of left chela of adult male remarkably elongate. .. P. svanus

Eyestalks hardly reach the base of terminal joint of antennular peduncle. ..

A single obliquely longitudinal crest on the outer surface of left palm. P. costatus

Two obliquely longitudinal crests on outer surface of left palm. .. P. bicristimanus

Antennal peduncle very distinctly shorter than antennular peduncle. P. rostimanus

Antennal and antennular peduncles of equal length P. investigatoris

Pleocyemata

## Palaemon miles (Herbst 1791)

(Pl. XVI, 2)

Cancer miles Herbst 1791, p.19, pl.22, fig.7.

Alpheus edwardsi Henderson 1893, p.413; 1915, p.28; Nobili 1905, p.13; Alcock 1905, pp.67-68, pl.5, fig.5 (Synonymy); Southwell 1906, p.240; Stebbing 1910, p.354; Sundara Raj 1927, p.133; Makarov 1938, p.157; Gravely 1941, p.77; Kamalaveni 1949, pp.80-81.

Material: Several specimens. Mundagam (5-9-67) 15 specimens, carapace length 5.8 to 8.6 mm, including 2 berried females; Pamban (25-4-67) 1 male, 8.2 mm; Thanithurai (2-8-67) 4 males 6.2 to 7.1 mm; Rameswaram (5-9-67) 11 specimens, 5.75 to 8.5 mm; Irumeni (31-5-67) several specimens, 7.35 to 15 mm; Cuddalore (9-11-68) 1 male, 10.5 mm. Collected from shallow areas. Depth of occurrence: 1 - 2 m.

Inhabits shells of Oliva gibbosa, Strombus spp. Natica didyma, Nassa spp. Bursa spp. and other narrow mouthed gastropod shells.

Description: Carapace broader than long, highly depressed. A number of tufts of setae and granules, present just posterior to the cervical groove. Rostral appendage longer than ophthalmic scales and with spinulose edge. Ophtalmic peduncles reaching to the middle of third antennular joint. Antennal peduncle slightly longer than antennular peduncle. Antennal scale hardly bifurcate, its outer limb falls short of the base of last antennal segments. Left cheliped vastly larger than right. Chela turning inwards even in fully extended condition. Merus directing outwards the chela being flexed towards the inner side. Dactylus about half length of propodus, including fixed finger. Propodus with rows of large spines on outer margin, these pointed spines curving forwards. Similar stout pointed spines present on the inner margin also. Dactylus also bearing similar stout spines in three definite rows, separated by longitudinal grooves. Upper surface of chela granular. Setae being arranged in tufts on either side of the cutting edges. Carpus, merus and ischium with granular upper

surface with well defined spines and setae on the inner margin. Second and third legs bearing spines and centered granules on all segments except the dactylus with well marked longitudinal groove and corresponding ridges with rows of setae and granules in between. The abdomen having a fleshy process arising ventral to the first and second pleopods on the left side, probably for holding inside the shell.

Colour: Light red spots present cephalic region and chelipeds. Last two legs have red bands on the proximal 2/3 of propodi. The general body colour varies from cream to ash or even light blue or violet.

Distribution: South Africa (Stebbing 1910); Ceylon (Henderson 1893; Southwell 1906); Palk Bay (Sundara Raj 1927); East coast of India (Henderson 1893; Kamalaveni 1947); Mergui Archipelago (de Man 1888); Malaya (Miers 1880); Australia (Dana 1852).

Dicerones neozeylanicus de Man 1888

(Pl.XVI, 3)

Dicerones neozeylanicus de Man 1888, p.228, pl.15, fig.4,5,6; Henderson 1893, p.413; Alcock 1905, pp.63-64, pl.15, fig.2 (Synonymy); Southwell 1906, p.214.

Material: 18 specimens. Tuticorin (6-8-67) 1 male, carapace length, 14.5 mm; Mandapam, Gulf of Mannar (2-12-69), 1 male, 19 mm; 1 female, 23.4 mm; Off Pudumadam (7-1-69), 1 female, 20.2 mm; 1 male, 24.75 mm; Pamban, Gulf of Mannar (12-11-69), 4 males, 19 to 22.5 mm; 5 females, 17.6 to 24.5 mm mm (2 berried); Mandapam, Palk Bay (3-3-67), 1 male, 25.1 mm; Athankarai

(13-7-69), 1 male, 27 mm; Thirupalaikudi (10-8-68), 1 female, 17.25 mm; Gopalapatnam (17-8-69), 1 female, 19 mm. Collected from trawl catches. Depth of occurrence: 6 - 12 m.

Description: Carapace similar to that of P. dispersus. Eyestalk short, less than the anterior border of carapace, extending upto base of last antennular segment. The inner fork of antennal scicle reaching base of last antennal joint, while outer one extending almost to the middle of terminal segment of antennal peduncle. Antennal flagellum longer than carapace, unlike the material described by Alcock (1905), and setose.

Chelipeds and second and third legs have spinose margins although outer surface have sharp conical tubercle and not spines, each tubercle being provided with a wreath of short stiff radiating setae. Left chela has merus which is as long as broad. Palm broader than long, fingers with double rows of spines on outer margins. Second and third legs have granular outer surface of meri wile in third leg ischium has blunt tubercles with radiating setae. Propodi with upper row of spines and granules on the outer aspects. Dactyli devoid of granules, but with an upper row of small spinules and longitudinal grooves and ridges, with long setae on the inner surface.

Colour: In live specimens carapace greyish in the cephalic region, brown in the branchial region. Rostrum and antennal scales brown; eyestalks with one inner and two outer longitudinal stripe of dark grey grey colour. Antennal peduncles and flagella with grey spots; propodi and dactyli of legs orange, with light shades near joint. Meri and carpi ash grey; fourth and fifth legs brown; pleopods orange as also uropods. Abdomen white. Telson paler in shade with grey dorsal shield. Legs bear long shining setae.

These hermit crabs prefer light shells with wide mouth. They are in the habit of remaining buried in the bottom sand or mud during day time.

Distribution: Gulf of Manaar (Henderson 1893; Southwell 1906); East coast of India (Alcock 1905); Mergui Archipelago (de Man 1888).

## Manaarus diacanthus (Herbst 1791)

(Pl.XVI, 4)

Cancer diacanthus Herbst 1791, p.17, pl.12, fig.5.

Manaarus diacanthus Henderson 1893, p.412; Alcock 1905, pp.62-63, pl.15, fig.3; Southwell 1906, p.214; Sundara Raj 1927, p.132; Boone 1933, p.26; Reddi 1955, p.561; Kamalaveni 1949, p.31.

Pagurus pilus Fabricius 1798, p.412.

Material: Several specimens. Mangalore (19-1-68), 12 males, carapace length 11 to 22 mm; 6 berried females, 10 to 18 mm; Calicut (24-1-68), 43 males, 10 to 26 mm; 6 females, 11 to 24 mm; Ashiedo (4-4-67), 6 males, 11 to 23.5mm 6 females, 12.6 to 14.35 mm; Point Calimere (25-9 -68), 1 male, 16.5 mm; Nagapattinam (20-3-67), 7 males, 14.5 to 26 mm; 1 female, 18.2 mm; Cuddalore (9-11-68), 1 male, 27.8 mm; Kakinada (8-4-68) males 14.9 to 21.6 mm; 1 female 15 mm. Collected from shrimp trawls. Depth of occurrence: 10 - 20 m.

Occupies shells of Bursa bulbosa, Natica spirata, Murex cancellatus, Tuba dolium, Babylonia spirata, Pleuroploca filosa, Murex spp. Trochus spp. Phalium areola, Turritella spp. Murex ternus, and other gastropod shells with wide opening.

Ornamentation: Carapace with granular tubercles on the anterior border; superior portion of carapace provided with many spinules and serrated setose ridges. Posterior portion of carapace with vesicular granules. Rostrum long, nearly 1/3 eyestalks and bear spines on the sides of distal half. Eyestalks long about 3/5 the anterior border of carapace. Ophthalmic scales large, with spinulose free edge. Antennular peduncle longer than antennal peduncle; antennal scale with outer long fork reaching almost to the base of last antennular segment, inner one extending only upto the middle of penultimate segment. Antennal flagellum 1.7 times as long as carapace.

Chelipeds bear claw-shaped spines on the outer surface of palm. Similar spines present on the other legs also. Left larger cheliped nearly twice the length of carapace; chela as long as carapace; merus, carpus and palm of equal lengths; carpus longer than broad, palm broader than long. Superior margin of merus, propodus and dactylus with strong spines in rows. Setae restricted to the margins on large chela, small chela being more hirsute. Second and third legs having spinulose anterior margins. Propodus with longitudinal rows of spines on superior aspects and with only one row of spines on the upper surface of the dactylus. Dactyli 1.5 times as long as propodi.

Colour: Body and legs yellow or yellowish brown in fresh condition with pale ventral surface. Setae also yellowish brown in colour.

Distribution: Arabian Sea (Alcock 1905); Ceylon (Southwell 1906); Gulf of Mannar (Sundara Raj 1927; Henderson 1893); East coast of India (Henderson 1893; Alcock 1905; Reddi 1955; Kamalaveni 1949).

This is the first report of P.diagonus from southwest coast of India.

## Macrura sentus (Fabricius 1798)

(Pl.XVI, 5)

Pagurus sentus Fabricius 1798, p.412; Olivier 1811, p.644; Milne Edwards 1836, p.284; 1837, p.236; 1848, p.64.

Diogenes sentus Henderson 1893, p.414; Nobili 1903, p.15; Alcock 1905, pp.64-65, pl.6, fig.1 (Synonymy); Stimpson 1907, p.201; Sundara Raj 1927, p.135; Reddi 1955, p.561; Gravely 1941, p.77.

Material: 24 specimens. Dungevalasi, Palk Bay (6-2-68), 4 males, carapace length, 11 to 15.9 mm; Nagapatnam (20-5-69), 2 females, 12.5 (berried), 13 mm; 7 males, 12 to 15 mm; Cuddalore (9-11-68), 13 males, 13.1 to 20.9 mm; 2 females, 15.2 to 13.6 mm. Collected from commercial shrimp trawls. Depth of occurrence: 2 - 15 m.

Inhabits shells of Natica spp. Maroon range.

Description: Eyestalks shorter, only less than 2/3 anterior breadth of carapace. Rostrum long, about half eyestalks. Antennal and antennal peduncles of equal length. Antennal scicle with well defined inner fork reaching middle of penultimate segment of antennal peduncle. Outer fork extending beyond base of last antennal segment. The flagellum little longer than carapace. Carapace with a single row of round granules along anterior margin and transverse rows of similar granules with setae arising from their bases in the cephalic region.

Chelipeds and exposed surface of other legs finely and copiously granulated although borders of the segment of chelipeds as well as the second and third legs are spinose or spinulose. Distribution of setae also

restricted to the margins. Spines arranged in two or three definite rows along the inner superior margins of merus, carpus, propodus and dactylus of the chela. Strong spines arranged in a single row along the superior margin of second and third segment of second and third legs. Granules disposed in two rows on upper border of propodus, on the sides these granules being in transverse rows. Dactyli have fewer granules but with longitudinal grooves and ridges. Long setae only on the inner margin of dactyli only.

Colour: Uniformly yellowish brown. Chelae, second and third legs, eyestalks antennules, antennae, cephalic region of carapace and setae of the same colour. Ventral surface of a lighter shade. Abdomen and other appendages cream coloured.

Distribution: Gulf of Mannar (Sundara Raj 1927); Palk Bay (Henderson 1893); East coast of India (Alcock 1905; Henderson 1893); Mergui Archipelago (Alcock 1905); Andamans (Alcock 1905).

## Pilumnus sayanus Heller 1865

(Pl.VI, 19-21)

Pilumnus sayanus Heller 1865, p.83; de Man 1888, p.236; Henderson 1893, p.417, 1915, p.28; Alcock 1905, pp.68-69, pl.6, fig.6 (Synonymy); Grant and Mc Culloch 1907, p.55; Kemp 1915, p.251; 1918, p.254; Sundara Raj 1927, p.133; Pamikkar and Aiyar 1937, p.296; Ramtampader 1937, p.504; Yap-Chiongco 1938, p.203; Gravely 1941, p.77.

Material: Several specimens: Mandapam (12-5-67 and 17-11-67) several specimens carapace length 4.1 to 7 mm (3 berried females); Krusadai Island (12-10-69) 15 specimens, 3.1 to 5.2 mm; Athankarai (28-3-68) several specimens 2.8 to 5.3 mm from river mouth. Collected from shallow waters. Depth of occurrence: 1 - 2 m.

Inhabits shells of Cerithium spp., Turritella spp., Pyrene spp.

Description: Carapace moderately elongated, with anterolateral margins finely serrated. Rostrum slender, not reaching the tip of ophthalmic scales. Ophthalmic scales large with teeth on antero-lateral margins. Eyestalks stout, reaching middle of last antennal joint and beyond third segment of antennular joint. Antennular peduncles longer than antennal peduncles. Antennal flagellum shorter than carapace and less setose. Antennal scales straight with spines on inner aspects and almost reaching base of last antennal joint.

Chelipeds unequal, left being vastly longer, about 2½ times length of carapace, closely granulose, more finely on hand. Carpus longer than palm and merus. Palm longer than broad with teeth on the inner border along the outer longitudinal carina. Teeth present on the inner margin of merus, carpus and dactylus. Dactylus less than half length of palm.

Colour: General body colour grey or pale yellow with orange or yellow spots scattered on the legs and carapace.

Distribution: Gulf of Mannar (Henderson 1893; Sundara Raj 1927); Palk Bay (Henderson 1893); East coast of India (Gravely 1941; Panikkar and Aiyar 1937); Mergui Archipelago (de Man 1888); Malay Peninsula (Kemp 1918); Nicobar (Heller 1865); Philippines (Estampador 1937; Yap-Chiongco 1938); Australia (Grant and McCulloch 1907).

## Alpheus scaphus Henderson 1893

(Pl.VII, 7 - 9)

**Alpheus scaphus** Henderson 1893, p.418, pl.39, fig.7,8; Alcock 1905, pp.70-71, pl.6, fig.7; Southwell 1906, p.214; Stebbing 1908, p.24; 1910, p.355; 1920, p.21; Lenzie 1926, p.156; Sundara Raj 1927, p.153; Barnard 1947, p.376; 1950, p.443.

**Material:** 1 specimen. Off Mandapam, Palk Bay (22-4-71). 1 male, carapace length, 13 mm, in shell of *Murex* larva. Collected from trawl catches. Depth of occurrence: 5- 10 m.

**Description:** Carapace moderately elongate. Rostrum in the form of a slender spine, shorter than ophthalmic scales. Antennular peduncle longer than antennal peduncle; antennal acicle a simple spine, strongly spinose along inner edge, reaching base of terminal joint of peduncle. Eyestalks about 4/5 length of anterior breadth of carapace, surpass base of terminal antennal joint; but hardly reaching the last antennular segment.

Left cheliped vastely longer than right. Merus shorter than carpus which is slightly shorter than palm. Palm longer than broad. Merus with teeth on the outer margin where as the inner border of carpus is serrated. Propodus and dactylus have strong serrations on the inner surface. Outer surface of palm nearly smooth. An oblique ridge starting from the outer upper surface of base of chela and extending to middle towards the distal end.

**Colour:** Cephalic region with brown marks; chelipeds and legs with similar bands across the segments. Ground colour of body and proximal three segments of second and third legs whitish. Propodi and dactyli brown with long brown setae. Antennular flagella yellowish. Other appendages white.

[redacted] in addition to similar row a little towards the middle of the palm. [redacted]ble finger with an outer double row of spines in addition to a chief [redacted]ning spines on the inner aspect. The cutting edges meeting closely throughout the entire end. The remaining portion of the chela with scattered spines and setae. Second and third leg setose and with spines on lower side of carpi.

Colour: Light brown to ash grey in colour, with setae of same colour in fresh specimens.

Distribution: West coast of India (Southwell 1909); Gulf of Manaar (Southwell 1906); Palk Bay (Southwell 1906); east coast of India (Alcock 1905).

Genus Anigmlus Dana

Chelipeds and second and third legs regularly transversely acutellated, the free edge of the z scutes being beautifully ciliated. Chelipeds equal, similar or very nearly so, fingers of both hands short, blunt and deeply spooned.

Abdominal appendages in female biramous, in the typical A. anigmlus the first three legs carry large leaf-like lamellae which aid in forming the brood-pouch.

There is only one species of this genus collected during the present studies.

Key to the Indian species of Anigmlus

1. Carapace flat, its greatest breadth exceeding the length .. A. striatus

- Carapace not depressed, longer than broad. 2

Distribution: East coast of India (Henderson 1893; Alcock 1905); Gulf of Mannar (Henderson 1893; Southwell 1906; Sundara Raj 1927); South Africa (Barnard 1947; 1950); Western Indian Ocean (Laurie 1926).

## Pinnotheres rectimanus Miers, 1884

Pinnotheres rectimanus Miers, 1884, p.262, p.27, fig.e; Henderson, 1893, p.419; Lanchester, 1902, p.366; Alcock 1905, p.71, pl.6, fig.8; Nobili, 1906e, Southwell, 1906, p.213; Thompson, 1943, p.415.

Material: 1 specimen. Mandapam, Gulf of Mannar (2-12-69), 1 male, carapace length, 10.5 mm. Collected from trawls. Depth of occurrence: 5 - 10 m.

Description: Carapace more elongated than P. costatus with more oblique antennal angles. Inner lower border of left large cheliped not spinulose. Palm of hand as high as long. Outer surface of merus carpus and palm granulose. Outer margin of palm with a series of well developed spines as also on its posterior border. Merus with a few strong spines on the inner distal margin. A longitudinal row of smaller spines on the superior inner aspect of merus. A strong spine and a tubercle on the outer margin of merus at the distal end. Fingers devoid of gap in between the cutting edges when closed. Inner margin of fixed finger provided with a row of blunt spines, with setae in between. The cutting edges having series of blunt tubercles.

Colour: Carapace, large antennal scales, first antennular segments and antennal flagella bluish in colour. Antennular peduncle and flagella white as also the antennal peduncles. Eyestalks brown with reddish tint near the cornea. Setae white.

Distribution: East coast of India (Alcock 1905); Gulf of Mannar, Ceylon (Southwell 1906); Red Sea (Nobili 1906); East Indies (Miers 1884).

Macrura investigatoris Alcock,1905

(Pls.VII, 13 - 15; XVI, 6)

Macrura investigatoris Alcock,1905, p.71, pl.6, fig.9;
Southwell, 1906, p.213; 1909, p.100.

Material: 3 specimens. Mandapam (15-9-69), 1 male, carapace length,10 mm; Off Pudumadam, Gulf of Mannar, (7-1-70), 1 male, 8 mm; Cuddalore (9-11-69), 1 berried female, 11.7 mm. Collected from commercial trawl catches. Depth of occurrence 5 - 20 m.

Description: Carapace elongate and more narrow than in P. sanctus. Anterior end of ophthalmic scales with spines throughout its free edge, decreasing in size from the inner side. Eyestalks slender, reaching short of middle of last segment of antennal peduncle and a little beyond the base of third antennular segment. Antennular peduncle longer than antennal peduncle. Antennal scale straight, falling well short of the base of terminal antennal segment.

Left Cheliped longer, lower outer margin of merus with well developed, anteriorly curved spines. Carpus with a prominent row of sharp spines on the inner upper border ending distally in two or three large spines and with similar spines scattered on the upper and outer surfaces. Palm with strong spines at the lower outer aspect starting from the proximal end, being arranged longitudinally in double rows and becoming single towards the distal end. Three longitudinal rows of spines. On the inner upper

Eyestalks longer than anterior border of carapace not strikingly hirsute .. A. longirostris

Eyestalks shorter than anterior border of carapace; chelipeds and legs well ciliated. .. A. aniculus

Aniculus strictus (Herbst 1804)

(Pl. XVI, 1)

Cancer strictus Herbst 1804, p.25, pl.61, fig.3;

Parapeus strictus Olivier 1811, p.647; Hilgendorf 1878, p.820, pl.2, fig.8; Ortmann 1892, p.285; Borradaile 1900, p.425; Nobili 1903, p.15.

Aniculus strictus Henderson 1893, p.422; Alcock 1905, p.97, pl.7, fig.4; Southwell 1906, p.215; Edmondson 1926, p.24; 1933, p.226; 1946, p.263; Laurie 1926, p.159; Thompson 1943, p.417; Barnard 1950, p.431.

Material: 3 specimens. Off Cochin (14-7-67). 3 males, carapace length 11.5 to 16.6 mm, in shells of Phalium areola. Collected from deep sea trawler. Depth of occurrence: 200 m.

Description: The thin and flat carapace broader than long devoid of setae, with almost straight anterior margin. Eyestalk nearly 1.3 anterior border of carapace. Eyestalks as long as antennular peduncles and longer than antennal peduncles unlike Alcock's material. Ophthalmic scales separated with pointed anterior tips. Antennal scale simple and spineless, extending only upto 1/3 length of last antennal segment, flagellum 1.4 times carapace length.

Chelipods similar, left slightly longer than right. Fingers open and close almost in horizontal plane. Margin of scutes or rings without spines but with setae. Merus longer than broad, carpus broader than long. Short tufts of bristles on fingers, coarser than other species. Dactyli of second and third legs hirsute on both upper and lower margins, other segments with setae on the ventral surface also. Sternal plates exceedingly broad as a result of much flattened body to suit shells like Phalium and Cassis with the result the bases of external maxillipeds almost as separated as in Pseudocypho.

Colour: In preserved specimens ground colour cream with reddish margins on scutes.

Distribution: South Arabian coast (Thompson 1943); Western Indian Ocean (Hilgendorf 1878; Laurie 1926); South Africa (Barnard 1950); Gulf of Manaar (Henderson 1893); Gulf of Manaar, Ceylon (Southwell 1906); East coast of India (Alcock 1905); Andamans (Alcock 1905); Pacific Ocean (Edmondson 1926, 1933, 1946).

## Genus Calcinus Dana 1852

Chelipods unequal, left larger; fingers moving obliquely or vertically, spooned and with calcareous tips. Fourth pereiopods subchelate, fifth chelate. Carapace elongate with anterior portion very firmly calcified. Hard parts densely procellanous in texture and generally vividly coloured.

Closely resembles Clibanarius differing mainly in the form of the chelae and texture of hard parts of exoskelaton.

This genus occur in tropical as well as subtropical waters; represented in the present collection by four species.

## Key to the Indian species of *Calaiuus*

1. Ocular peduncles not longer than anterior border of carapace; superior border of right hand entire. Inferior border of propodus and dactylus of the third pair of legs not hairy .. *C. herbsti*
- Ocular peduncles longer than anterior border of carapace; superior border of right hand serrated; posterior border of dactylus and proximal end of propodus of third legs hirsute. .. .. 2
2. Ocular peduncles 1 1/3 anterior width of carapace; second and third legs with large alternating blue and dark red cross bands. .. .. .. *C. gloriosa*
- Ocular peduncles 1 1/2 anterior border of carapace; legs without transverse bands. .. .. 3
3. Colour reddish brown; inferior aspects of propodus of third leg bordered with long bristles. .. .. *C. spinosus*
- A violet ring on the dactylus and long bristles absent on lower aspect of propodus of third legs. .. *C. latens*

### *Calaiuus herbsti* de Man 1887

*Calaiuus herbstii* de Man 1887, p.437; 1890, p.270; 1900, p.474; 1902, p.740; Henderson 1896, p.518; Borradaile 1898, p.462; Nobili 1900, p.21; 1907, p.368; Alcock 1906, p.828, fig.4; 1905, p.53, pl.5; Yap-Chiongco 1939, pp.205-206.

*Calaiuus herbsti* Pise and Sarma 1955, pp.41-49, fig.6, A,B,C; pl.2, 1-4 (Synonymy).

Material: 17 specimens. Mandapam (4-8-67) 1 male, 7 mm; 1 female, 7.75 mm; Rundugal (18-9--69) 1 male, 7.8 mm; 1 female, 7.25 mm; Andaman Island (20-8-69) 1 male, 13.25 mm; 3 females, 6.75 to 8.25 mm (2 berried); Minicoy Island (10-4-69) 5 males, 6.75 to 8.5 mm; 2 females, 6, 10 mm (berried); (20-5-70) 1 berried female 7.6 mm; Kavaratthy Island (22-12-65) 2 males, 10.5, 11 mm. Collected from shallow waters. Depth of occurrence: 1-2 m.

Description: Eyestalks a little longer than the anterior border of the carapace, longer than the antennal peduncles and antennular pdunclos. Antennular peduncles longer than antennal peduncles. Ophthalmic scales stout with pointed tips. Scut antennal scicles reach almost the distal ends of penultimate segments of antennal peduncles, with serrated upper borders. Left cheliped vastly larger than right, smooth, without spines. Carpus with an oblique groove on the outer surface across the near end, 1½ times as broad as long. Merus as broad as long. Palm of chela as high as long; dactylus shorter than palm. Inner aspects of fingers with a few tufts of setae, there being no gap between the cutting edges when closed. Second and third legs shorter than large cheliped, their joints smooth without spines except one on the distal end of the anterior border of the carpus; dactyli shorter than propodi, dactylus with a few tufts of setae near the tip, but no thick brush as in C. gaimardi.

Colour: Cephalothorax and abdomen ash grey; chelipeds blue black with white tips. Second and third legs orange with brown long bands on merl and carpi; claws dark. Dactyl white with brown cross band near the tip. Anterior half of eyestalk orange as also antennal and antennular flagella. Posterior half of eyestalk and first two segments of antennal peduncles and antennal scicle white in colour.

Distribution: Gulf of Aden (Thompson 1943); Laccadive Archipelago (Henderson 1896; Alcock 1905; 1906); Gulf of Mannar, Ceylon (Henderson 1896); Western Indian Ocean (Lenz 1905; 1910; Balss 1912; Bouvier 1915; Alcock 1905); east coast of India (Alcock 1905); Andaman Island (Alcock 1905); Viet Nam (Fize and Serene 1955); Philippines (Estampador 1937; Yap-Chiongco 1938); Japan (Terao 1913); Australia (Whiteleggo 1903; Grant and Mc Culloch 1907b); Pacific Ocean (Borradaile 1898; Alcock 1905; Nobili 1907; Calman 1909; Balss 1912; Edmondson 1923; 1925; 1926; 1933; 1946; Gordon 1933; Forest 1951; 1953; Holthuis 1953).

## Calcinus elegans Milne Edwards 1836

(Pl. VI, 4-6)

Pagurus elegans Milne Edwards 1836, p.278, pl.13, fig.2; 1848, p.63; 1837, p.228.

Calcinus elegans Dana 1852, p.458, pl.28, fig.10, a-e; Heller 1865, p.88; de Man 1890, p.108; Ortmann 1892, p.294; Henderson 1896, p.519; Whiteleggo 1897, p.143; Borradaile 1898, p.461; Alcock 1905, pp.55-56, pl.5, fig.2; Southwell 1906, p.215; Stimpson 1907, p.208; Stebbing 1910, p.353; Terao 1913, p.357; Edmonson 1923, p.26; 1926, p.23; 1946, p.263; Estampador 1937, p.505; Yap-Chiongco 1938, p.206; Thompson 1943, p.415; Barnard 1950, p.438; Forest 1953a, p.55; Holthuis 1953, p.41.

Material: 6 specimens. Miniscy Island (20-1-70) 2 females, 15.1, 15.6 mm (berried); (21-1-70), 4 females, carapace length 6.75 (berried) to 13.5 mm. Collected from shallow water. Depth of occurrence: 1-2 m.

Description: Eyestalks 1½ length of anterior border of carapace, longer than antennal and antennular pedunculo. Antennal scale reaching the proximal portion of last segment of antennal peduncle.

Left cheliped vastly larger than right, bearing a few spines on the far end of the merus and carpus and some white granules on the distal border of carpus. Fingers and anterior portion of palm with closely arranged pearly tubercles of small and large sizes; fingers only meeting at the tips. Right cheliped with serrated margins, upper margin of palm being strongly so, carpus less so and merus least. Left cheliped also with pearly tubercles. Second and third legs have strong and long setae on the posterior border; those of third leg forming a thick brush at the distal end of propodus and proximal end of dactylus.

Colour: Chelipeds yellowish, grey fingers with white pearly tubercles. Second and third legs being marked with alternate broad cross bands of white or light blue and red or maroon, dactyli blue and red with red spots bearing setae of same colour. Base of eyestalks and ophthalmic scale red, rest of eyestalk light blue. Antennules antennae and third flagella yellow in colour. Cephalic region of carapace with white a few red spots. Fourth and fifth legs bluish with red patches. Setae throughout the body red in colour.

Distribution: Laccadive Archipelago (Henderson 1896; Alcock 1905; 1906); Maldive Archipelago (Alcock 1906); South Africa (Stebbing 1910; Barnard 1950); Western Indian Ocean (Laurie 1926); Gulf of Mannar, Ceylon (Southwell 1906); Philippines (Estampador 1937; Yap-Chiongco 1938); Taiwan (Lee 1969); Japan (Terao 1913); East Indies (Buitendijk 1937); Pacific Ocean (Milne Edwards 1836; Dana 1852; Borradaile 1898; Nobili 1907; Stimpson 1907; Edmondson 1925; 1925; 1933; 1946; Forest 1953; Holthuis 1953).

## Calcinus gaimardii (Milne Edwards 1848)

(Pl.VI, 7-9)

Pagurus gaimardii Milne Edwards 1848, p.63.

Calcinus gaimardii Dana 1852, p.457; 1855, pl.28, fig.9; Heller 1865, p.87; Ortmann 1892, p.294; 1894, p.32; Whitelegge 1898, p.143; Borradaile 1898, p.462; Alcock 1905, p.56, pl.5, fig.3; 1906, p.829; Barnard 1947, p.376; 1950, p.439; Southwell 1905, p.215.

Calcinus gaimardi Buitendijk 1937, p.268; Pike and Serene 1955, pp.49-58, fig.7, A, B, B1, C, fig.8, A, B, C; pl.2, 5, 6, 7, 8 (Synonymy).

Calcinus laevis-marinus Haswell 1882, p.760; de Man 1887, p.439; 1888, p.226; Alcock 1905, pp.57-58.

Material: 2 specimens. Miniscy Island (21-1-70), 1 male, carapace length 12.2 mm; (20-3-70) 1 male, 9.9 mm; Andaman Island (13-8-69) 1 berried female, 7.6 mm. Collected from shallow water. Depth of occurrence: 1-2 m.

Inhabit shells of Turbo sp. and Cerithidium sp.

Description: Rostrum conical and bluntly pointed, almost reaching base of ophthalmic scales. Cervical region of carapace pitted dorsally. Ophthalmic peduncles slender, one and half times front border of carapace. Antennal acicle with pointed spines and overlapping terminal joint of peduncle. Antennular peduncle decidedly shorter than eyestalks.

Cheliped unequal, left one being much larger than right. Merus bearing single spine on disto-lateral surface. Carpus also with a similar

spine on inner aspect, distally towards dorsal surface. Unlike Alcock's material, carpus with an external groove and there without well defined spine. The fingers and palm with small granular outgrowths, becoming more conspicuous towards lower outer margin. Inner surface of palm near lower border with a row of blunt, round granules of considerably larger size, in addition to a few similar but smaller granules, irregularly scattered above this row. Fingers meeting only at tips. The upper border of smaller, right cheliped serrated, cut surface granulose. Merus and carpus with spines similar to those of left chela. Second and third legs surpassing chelipeds. Smooth except for a spine on the far end of anterior border of carapace. Posterior border of dactyli and distal 2/3 of posterior border of propodi of third legs with thick brush of long, stiff setae, remaining portion of the leg being sparsely setose.

Colour: In fresh specimens the chelipeds and legs rich chestnut brown with white tips, except in second and third legs with black terminal claws, but part of the dactyli just before claws white in colour. Basal 2/3 of eyestalk chestnut brown, distal portion bluish. Antennal and antennular flagella yellow. Antennules bluish. Rostrum with brown tip. Lateral sides of carapace brown; anteriorly, the dorsal surface being speckled with brown. Fourth and fifth legs brownish with white bands near the ends of the segments.

Distribution: Maldive and Laccadive Archipelago (Alcock 1905); South Africa (Barnard 1947); Gulf of Mannar, Ceylon (Southwell 1906); Mergui Archipelago (de Man 1888); Philippines (Tan-Chiongco 1938); Taiwan (Lee 1969); Japan (Terao 1913); East Indies (Dana 1852; Buitendijk 1937); Australia (Haswell 1882; Grant and Mc Culloch 1907; Stephenson, et al. 1958); Pacific Ocean (Dana 1852; Forest 1953).

The species is reported from Andamans for the first time.

## Caridina laevis (Randall 1839)

(Pl. VI, 10-12)

Palaemon laevis Randall 1839, p.195.

Caridina laevis Dana 1852, p.459; 1855, pl.28, fig.2; Heller 1865, p.88; Alcock 1902, p.329; 1905, p.58, pl.5, fig.5; Nobili 1906b, p.117, fig.5; 1906a, p.83, pl.5, fig.20; Balss 1957, p.269; Yap-Chiongco, 1938, pp.207-208; Bouvard 1950, p.438; Forest, 1958, p.85, figs.14-18; Pico and Serene 1955, pp.58-66, fig.9, A,B,C; pl.2, 9, 10, 11 (Synonymy); Lee 1969, pp.55-56.

Material: 2 specimens. Andaman Island (15-8-68), 2 males, carapace length, 6.5, 7.5 mm, in shells of Strombus sp. Collected from shallow waters. Depth of occurrence: 1-2 m.

Description: Carapace with rostrum short, pointed and triangular, more prominent than antennal angles. Eyestalks more than 1/3 anterior border of carapace, longer than antennular and antennal peduncles. Ophthalmic scales simple and pointed anteriorly. Antennular peduncle longer than antennal peduncles. Antennal scales with serrated outer margin and provided with a few spines on inner aspect, reaching nearly $\frac{1}{2}$ the terminal joint of antennal peduncle.

Left cheliped longer than right, upper border of merus faintly serrated. Upper border of carapace with a spinule at far end and bearing a conspicuous tubercle near middle at proximal end. The merus bearing a pair of spinules at far end near distal extremity. Setae sparsely arranged near inner aspect of fingers. Fingers meeting only at tips with obscure

teeth on their inner aspects. Right cheliped with large terminal teeth, distally on the inner side of the carpus. Superior surface of palm with a chest of 5 stout dark tipped spines extending the entire length of palm, each spine with setae at the base. Inner border of free finger also toothed. Tips of fingers typically opposed. Lower inner aspect of merus with two sharp and one blunt spine. Setae long and sparse. Second and third legs with distal teeth on carpus. Long thin tufts of setae on the distal end of propodus and dactylus, rest with sparsely arranged small setae.

Colour: In preserved specimens the colour of the bases of dactyli of second and third legs dark purple, rest of the body yellowish and light red.

Distribution. Red Sea (Nobili 1906; Balss 1916; Riddel 1911); Maldives (Alcock 1906); South Africa (Barnard 1905); Western Indian Ocean (Laurie 1926); Philippines (Rustompador 1937; Yap-Chiongco 1938); East Indies (Dana 1852; Haitendijk 1937); Japan (Terao 1913); Australia (Grant 1905; Grant and Mc Culloch 1907; Mc Neill 1926; Stephenson, et.al. 1958); Pacific Ocean (Randall 1839; Dana 1852; Shimpson 1907; Nobili 1907; Rathbun 1925; Forest 1951; 1953; Holthuis 1953).

This is the first report of the species from Andamans.

Genus Trapezioxanthus Henderson 1893

Carapace elongate. Ophthalmic scales large, rather slender and approximated. Antennal scale short and robust. Chelipeds dissimilar unequal, left being greatly larger; hands tumentose, fingers open and close in a nearly vertical plane finger tips chlorarcous and acuminate.

There is only one species of this genus represented in in the collections.

Key to the species of Trachycarcinus

Antennal scale truncate; anterior edge of ophthalmic scales spinulose throughout .. T. nanozarcinis

Antennal scale not truncate; only outer internal angle of the ophthalmic scales spinose; outer surface of left hand with dense mat of hairs. ..

Antennal scale acute lower border of left hand sinuous. T. longicarpus

Antennal scale hardly acute; lower border of left hand not sinuous. ... T. johnsoni

Trachycarcinus nanozarcinis Henderson 1893

(pl.VI, 13 - 15)

Trachycarcinus nanozarcinis Henderson 1893, pp.421-422, pl.39, fig.9, 10; 11; Alcock 1905, p.73; Nobili 1906b, p.80; Southwell 1906, p.217.

Material: 1 specimen. Off Pedmadam (31-12-67), 1 male, carapace length 11 mm. (Tip of the dactylus is broken). Collected from trawl catches. Depth of occurrence 15 m.

Description: Carapace elongated, well calcified anteriorly. Eyestalks slender; ophthalmic scales large with spine throughout the anterior margin. Antennal scale short and stout; flagellum with long setae throughout its length.

Chelipeds unequal greatly longer, hands tomentose, fingers opening and closing in almost vertical plane. Finger tips calcareous and pointed, finely and irregularly toothed with inner margins in contact when closed. Right cheliped extends as far as the commencement of dactylus of left cheliped.

more pubescent and with fewer spines than left. Legs slender and similar on both sides with moderately pubescent segments; dactyli almost as long as propodi and with hairy tips. Telson with finely toothed margin.

This species has been reported by Thurston from Gulf of Mannar in small cavities of corals. However, the present material has been found to inhabit wide-mouthed gastropod shell of Murex virgineus, like its congener, P. longicarpalis Bouvier.

Colour: Specimen preserved in alco-glycero formal was dull white with cream coloured setae.

Distribution: Gulf of Mannar (Henderson 1893; Alcock 1905; Southwell 1906); Red Sea (Nobili 1906b).

## Family Paguridae Dana, 1852

Characterised by the third maxillipeds set well apart at the base. The right cheliped usually vastly larger than left, left never larger than right though rarely subequal.

Most of the genera are inhabitants of deeper waters. But Pagurus has been found to occur in shallow waters also. This family is represented by three genera comprising five species in the present material.

### Key to Indian genera of Paguridae

1. Fingers opening and closing obliquely; vas deferens not protruding ... 2
   Fingers opening and closing horizontally. ... 5
2. A pair of appendages on the first and second abdominal segments of male only. ... 3
   A pair of appendages on abdominal segment of female only ... 4

Gill trichobranchiae (quadriserial). .. Pennaeurus

Gills phyllobranchiae (biserial); centrum obsolescent; abdomen spiral. .. Synaeurus

Gills thirteen on either side .. Pylaeurus

Vas deferens not protruding in the form of a tube. .. 6

Vas deferens produced on one or both sides into a tube; no paired appendages on the abdomen of male. .. .. 7

A pair of appendages on first abdominal segment of male only; gills thirteen on either side. .. Tauraeurynia

No paired appendages on abdomen of male; abdomen well developed, spirally coiled. .. Paeurus (=Euraeurus)

Gill trichobranchiae (quadriserial); right vas deferens forming short tube; a pair of appendages may be present on first abdominal segment of female only. .. Paeuriza.

Gill phyllobranchiae (biserial) .. .. 8

Both vasa deferentia protruded, left short and right long ending in a long filament; a pair of legs on first abdominal segment of female only. .. Xenotaeurus

Only right vas deferens protruding no paired legs on abdomen of female .. .. 9

Right vas deferens recurving over right flank on to the dorsal side of the abdomen. .. Cataeurus

Right vas deferens crossing beneath abdomen and ascends over left flank. .. Centraeurus

Only left vas deferens protruding no paired appendages on abdomen of female. .. .. 10

Left vas deferens coiled in a spiral. .. Dairaeurus

Left vas deferens simply curved. .. Anaeurus

Genus Pagurus Fabricius 1775

Carapace elongate, broad posteriorly and well calcified in front of the cervical groove. External maxillipeds widely separated at base; the exopodites of all three pairs of maxillipeds flagellate.

Chelipeds usually dissimilar and unequal, the right being much longer, very rarely subequal; fingers moving in a more or less horizontal plane, finger-tips calcareous, rarely corneous.

Fourth pair of legs subcheliform fifth pair being minutely or imperfectly cheliform; fingers very short and blunt.

Key to the Indian species of Pagurus

1. Eyestalks as long as or longer than the anterior border of carapace.
- Eyestalks distinctly shorter than anterior border of carapace.
2. Rostrum acute, projecting between the ophthalmic scales; upper border of right palm not overhanging the dactylus. ..
- Rostrum obsolescent; upper border of right palm overhanging base of dactylus as a lobe. .. P. pexamanicius
3. Palm of left cheliped longer than fingers; left cheliped and 2nd and third legs longitudinally striped in red throughout their length.
4. Rostrum broadly triangular and acute; a crest lying diagonally opposite base of dactylus. .. P. sabae
- Rostrum rounded, not acute; no diagonal crest opposite to base of dactylus; a keel-like prolongation on lower portion of inner lateral surface of carpus. .. P. balkanoii
- Fingers of left chelipeds longer than palm; only merus of chelipeds and legs longitudinally striped. .. P. investigatoris

Rostrum not so prominent as antennal angles of carapace; right cheliped straight and rather slender; peduncles of antennules longer than those of antennae. .. .. 6

Rostrum acute, projecting between the bases of ophthalmic scales; right cheliped enormously massive and having the wrist and hand permanently deflexed; antennal peduncles as long as antennular peduncles. .. P. *ianitor*

Chelipeds densely tomentose, wrists and hands being buried in a shaggy covering. .. P. *messulai*

Chelipeds with a short patchy tomentum, not concealing surface sculpture; a pin-hole foramen on under surface of carpus of one or both chelipeds. .. .. 7

Entire outer surface of carpus of right cheliped spinose. P. *penhirsum*

A longitudinal groove on upper surface of carpus of right cheliped, always free of spines. .. P. *sculptipollicatus*

*Pagurus kulkarnii* Sankolli 1962

(Pl.VII, 16-18)

*Pagurus kulkarnii* Sankolli 1962, pp.136-142.

Material: Several specimens. Kavaratti Islands (10-10-69) many specimens, carapace length, 5 - 6.1 mm; (20-2-68) several specimens 5.7 - 7.3 mm (6 berried); Bangaram (12-8-68) several specimens, 5 - 8.1 mm; Thenithurai, Palk Bay (8-8-68) 5 males, 6 - 7 mm; 1 female, 6.1 mm; Kacha Tivu, Palk Bay (15-3-69) 5 males, 7.1 - 8.5 mm; 6 females, 6.3 - 6.5 (3 berried). Collected from shallow waters. Depth of occurrence: 1-2 m.

Description: Rostrum roughly triangular, less prominent than antennal angles. Ocular peduncle slender, slightly dilated at the base; cornea not dilated. Eyestalks extend to middle of last joint of antennal and antennular peduncles. Antennal peduncle equal in length to the antennular peduncle. Antennal scale slightly curved outwards, reaching a little beyond base of last joint of antennal peduncle.

Chelipeds unequal, right longer. The lower distal portion of merus having a heel-like semi-circular projection on the inner lateral surface projecting beyond its distal margin and with minute serrations on the entire margin. Carpus longer and broader than merus, with small tubercles dorsally. Outer upper margin having spinules, inner margin spinose and distal margin serrated. The lower inner surface produced into a distinct heel, projecting obliquely and provided with four minute teeth at the distal end. Palm as long as broad, upper margin with minute tubercles. Movable finger bearing very small conical tubercles. Finger tips corneous.

Colour: In live specimens colour varies from light brown to orange yellow with longitudinal stripes of chocolate brown on the chelipeds and second and third legs. Distal portion of eyestalks dark brown. Antennal flagella with chocolate cross bands.

Distribution: Bombay Coast (Sankolli 1962)

This is the first report of this species from localities other than the type locality, thus extending its distribution to the Gulf of Mannar and Palk Bay.

## Pontonia Jenkini (Alcock 1905)

Pontonia Jenkini Alcock 1905, pp.132-133, pl.11, fig.6; 1906, pp.832-833, pl.68, figs.2, 4; Balss 1916, p.10; Lenzie 1986, p.162; Estampador 1937, p.505; Yap-Chiongco 1938, p.208.

Pontonia Jenkini Bachmann 1964, p.37.

Material: 2 specimens. Andaman (August, 1969) 2 males, carapace length 14, 9.5 mm in shells of Trochus sp. Collected from shallow water.

Description: Carapace elongate; rostrum broadly triangular, with pointed tip more prominent than the antennal angles; eyestalk short, less than anterior breadth of carapace. Cornea dilated and reniform. Ophthalmic scales broad and separated at bases, pointed anteriorly and ending in a sharp spines. The narrow anterior portion having a groove on the dorsal surface. Antennular peduncle shorter than antennal peduncle and longer than ophthalmic stalks. Antennal scale elongated, slightly curved outwards and extending well beyond the base of the last antennal segment.

Cheliped unequal, right vastly longer and thickly covered with setae which partly conceal the spines and granules. Scattered granules and spines present on the dorsal surface of carpus and chela and their margins. Biting surfaces of fingers closing without leaving any space. Lower side of the cheliped less setose. Second and third legs with long setae on the upper surface although some scattered setae present on the lower margin too.

Colour: Colour of preserved specimens cream with light brown patches. Eyestalks dark brown; antennal flagella pale yellow.

Malaysia: Red Sea (Balss 1916); Maldives (Alcock 1905; 1906); Western Indian Ocean (Laurie 1926; Deshmukh 1964); Philippines (Estampador 1937; Yap-Chiongco 1938).

This is the first report of the species from Andamans.

Genus Hymenocerus A. Milne Edwards and Bouvier 1893

Carapace elongate, calcified in front of cervical groove. Rostrum broad and indistinct. Eyestalks stout; small ophthalmic scales placed wide apart. Antennal sciele long. Third maxillipeds separated at base. Chelipeds similar in form and sculpture, unequal, right being longer; fingers with corneous tips and moving in horizontal plane.

In males, vas deferens of right side produced into a long tube ending in a long tapering filament, that of the left side being in the form of a short conical tube or papilla. In male, abdomen with three pleopods on three to five somites on the left side. Female with four biramous pleopods.

Key to the Indian species of Hymenocerus

1. Outer surface of hand with a single median longitudinal row of spines. 2
- Outer surface of hand studded with numerous spines in addition to a conspicuous median longitudinal row. .. H. muricatus
2. Eyestalk shorter than anterior border of carapace. H. indicus
- Eyestalk as long as anterior border of carapace. H. gardineri
- Outer surface of hand and wrist covered with flat imbricating squamiform or scutiform tubercles. .. .. 3
3. Squames of hand in several longitudinal series. H. granulicholis
- Squames of the hand in two longitudinal series. H. scutelliciholis

## Xenocarcinus indicus Alcock 1905

(Pl. VII, 10-12)

Xenocarcinus indicus Alcock 1905, p.109, pl.12, fig.4; Kemp and Sewell 1912, p.26; Balss 1926a, p.110.

Material: 4 specimens. Off Cochin, (17-11-60), 2 males, carapace length 9, 9.5 mm; 2 berried females, 8.9, 10.5 mm. Collected from deep sea trawler catches. Depth of occurrence 350 m.

Description: Rostrum broadly triangular, less prominent than antennal angles, exposing ophthalmic segment. Eyestalks stout, dilated distally, less in length than anterior border of carapace, almost as long as second segment of antennular peduncle, reaching about middle of last antennal segment and with a few scattered setae dorsally. Ophthalmic scales widely separated, small and subtruncate. Antennal scale long, slender, reaching beyond middle of last segment of antennal peduncle. Antennal flagellum long and devoid of setae.

Chelipeds slender, unequal, right longer and copiously setose. Carpus as long as merus, longer than palm. Palm with longitudinal rows of teeth, longer than broad and longer than fingers. Inner border of carpus toothed. Palm with a few teeth on proximal end towards inner aspect. Finger tips corneous. Second and third legs surpass chelipeds by half length of dactyli. Carpus with a single spine on far end of inner border. Third leg longer than second leg with the dactylus as long as carpus and propodus combined.

Right vas deferens elongated and filamentous becoming coiled, left short and blunt.

Colour: Specimens preserved Alco-glycero-formol are light brown in colour.

Distribution: South west coast of India (Alcock 1905); East coast of India (Kemp and Sewell 1912); west coast of Africa (Bales 1926c).

## Xanthodius sternberghii Alcock 1905

(Pl.VII, 4-6)

Xanthodius sternberghii Alcock 1905, p.113-114, pl.12, fig.1; Bales 1926, p.110.

Material: 1 specimen. Off Cochin. (17-11-60), 1 male, carapace length, 9.25 mm. Collected from deep sea trawler catches. Depth of occurrence:350 m.

Description: Rostrum broadly rounded, more prominent than antennal angles with a few long setae near tip. The gastric region with a few symmetrically arranged long setae, a little behind anterior border. Ophthalmic segments exposed. Eyestalks dorsoventrally flattened, pear-shaped, shorter than antennal peduncles which are shorter than antennular peduncles. Cornea uniform, occupying nearly 1/3 length of ophthalmic peduncle. Ophthalmic scales distinct and blunt. Antennal scale long, slightly curved, reaching middle of last joint of antennal peduncle.

Chelipeds subequal, right being longer than left, twice as long as carapace and hairy. Carpus longer than palm and as long as merus. Merus with three spinules at inner near end. Flat, squamiform imbricating tubercules in several series cover upper surface of hand and carpus, with the free edges finely setose. Outer surface of palm and fixed finger spinose, fingertips corneous. Second and third legs exceeding chelipeds by half their dactyli. Upper surface of carpus and propodus with transverse ciliated squamiform

markings, a small spine dorsally at the far end of carpus. Dactylus of third leg as long as preceding joints combined. Right vas deferens elongated and spiral.

Colour: Preserved specimens are light brown in colour.

Distribution: Andaman Sea (Alcock 1905); Indian Ocean (Balss 1926c).

## Genus Spirocaris Stimpson, 1860

Carapace depressed, broadened posteriorly. Rostrum broad, obsolescent leaving the ophthalmic somite exposed. Eyestalks short, distally broadened; eyes large; ophthalmic scales separated. Antennal scale long.

Chelipeds equal or subequal and similar or right longer; fingers move horizontally, finger-tips calcareous. Left vas deferens of males protruding into a long rigidly-coiled, blunt-tipped tube; the right one does not protrude.

Spirocaris spiniger is the only species of the genus collected during the present investigations.

### Key to the Indian species and varieties of Spirocaris

1. Eyestalks with transverse ciliated lines dorsally, one of which forms a fringe to the base of the eye; antennal scale irregularly setose. .. S. spiniger

- Eyestalks dorsally smooth and nude; antennal scale long & plumose. 2

2. Two longitudinal rows of spines on carpus of cheliped. S. spiniger var. profundorum

- Three longitudinal rows of spines on carpus of cheliped and 2nd and 3rd legs. S.spiniger var. spinocarpus

- Upper edge of merus of cheliped carinate; upper surface of merus of 2nd and 3rd legs very sharply carinate, longtudinally, near anterior border. S.spiniger var. lenhomeris

Spirontocaris spiniger (de Haan 1849)

(Pl. XVII, 1)

Pontonia spiniger de Haan 1849, p.206, pl.49, fig.2; Stimpson 1859, p.248; Henderson 1888, p.72; 1893, p.425; 1896, p.524; Lanchester 1902, p.564.

Spirontocaris spiniger Alcock 1905, p.118; Nobili 1906, p.3; Southwell 1906, p.216; Stimpson 1907, p.214; Terao 1913, p.386; Yokoya 1933, p.91; Rutandon 1937, p.506; Haan 1937, p.26; Gurney 1939, p.98; Dechance 1964, p.38.

Material: 6 specimens. Mandapam, Gulf of Mannar (18-12-70) 2 females, carapace length 14.8, 14.9 mm (1 berried); Nagapattnam (2-3-67) 2 females 15.3, 14.5 mm (1 berried); Kakinada (8-4-68) 2 females 11.5, 15.4 mm (1 berried). Collected from the trawler catches. Depth of occurrence 5 - 10 m.

Occupies shells of Turbo spp. and Babylon spp.

Description: Carapace depressed, hirsute, rostrum blunt, less prominent than the antennal angles. Pyriform ophthalmic peduncles less than 2/3 the anterior border of carapace, much shorter than antennular and antennal peduncles and with transverse ciliated lines. Cornea large and reniform. Ophthalmic scales thin, lamella and fringed with setae. Antennular and antennal peduncles of about same length. Antennal scale elongated setose and curved reaching 1/3 the last antennal joint, flagellum very long. Chelipeds and legs tomentose with long setae on the edges of the legs also, adapted for swimming movements. Chelipeds subequal having squamiform ciliated markings with spines only on the carpus. Palm much longer than broad. Ciliated squamiform markings on the propodus and proximal portion of carpus obliquely disposed. Dactyli with longitudinal ciliated grooves on the outer aspect.

Colour: In fresh specimens ground colour orange; legs with brighter margins on 2nd and 3rd pairs. Anterior region of carapace with brown spots. Antennular and antennal flagella with dark transvers bands.

Distribution: Red Sea (Nobili 1906a); Madagascar (Deshayes 1964); Gulf of Mannar (Southwell 1906); east coast of Ceylon (Henderson 1896); east coast of India (Alcock 1905); Gulf of Martaban (Henderson 1893); Andamans (Alcock 1905); Philippines (Estampador 1959); Japan (de Haan 1849; Terao 1913; Yokoya 1933).

Family Coenobitidae Dana, 1852

Genus Coenobita Latreille 1826

Carapace elongate contracted and compressed anteriorly well clasified throughout except in certain parts of the branchiostegites. Rostrum almost obsolete. Eyestalks and ophthalmic scales juxtaposed; eyes

terminal and lateral with compressed stalks. Antennular peduncles extremely long; flagella compressed, rigid and truncated at tip, upper being much longer and broader than lower. Antennal peduncles compressed, the scale small and often fused with the second joint, flagellum long coarse and stiff.

External maxillipeds juxtaposed at base. Chelipeds unequal, left being very much stouter, all joints short, broad, and clumsy-looking; fingers with corneous or calcareous tips, movement vertical.

These land hermit crabs are abundant near the sea shore, inhabiting most localities. They occupy stout and heavy shells and form one of the most characteristic elements of the population of small tropical islands. They have been collected in large numbers from the islands in the Gulf of Mannar, near Mandapam. During day-time they remain below decaying vegetation and come out in groups at night. These animals feed mainly on vegetable matter although they are omnivorous at times. Species of the genus Coenobita are reported to be very common near the shore in the Laccadive Islands even during day-time.

Key to the Indian species of Coenobita

1. Antennal scicle not fused with 2nd joint of peduncle; eyestalks not strongly compressed; a brush of hairs on inner surface of right palm only. .. C. clypeatus

. Antennal scicle fused with 2nd joint of peduncle; eyestalk strongly compressed; a brush of hairs on the inner surface of both palms. .. ..

. An oblique file of upright laminar teeth on upper part of outer surface of left palm. .. ..

No such file of upright laminar teeth; coxae of 5th legs hardly more prominent in male than in female. .. C. savignyi

Outer surface of propodus of 3rd left leg flat, separated from anterior surface by a well defined crest; coxa of 5th right leg of male moderately produced, more so than left. C. rugosus

Outer surface of propodus of 3rd left leg convex and not sharply separated from the anterior surface; coxa of 5th right leg of male produced into a long curved tube. C. perlatus

## Cenochita olivencia Latreille 1826

(Pl.XVII, 2)

Cenochita olivencia Latreille 1826, p.277; 1829, p.77; Dana 1852, p.473, pl.30, fig.4; Heller 1865, p.82; de Man 1887, p.452; Henderson 1888, p.51; Borradaile 1898, p.459; 1899, p.425; 1901, pp.68-97; Yap-Chiongo 1938, p.213, pl.2, fig.12.

Cenochita olivencia Milne Edwards 1837, p.242; Nobili 1907, p.373; Alcock 1905, p.142, pl.15, fig.1, 1a; Southwell 1906, p.213; Yap-Chongco 1938, p.213; Pino and Serene 1955, pp.7-12, fig.1, A,B,C. pl.I, 1, (Synonymy).

Material: 1 specimens. Koosbur Island. (16-4-60) 1 male, carapace length 3' mm infested with two rhizocephalan parasites. Collected from sea shore.

Description: Carapace with numerous pits on the dorsal side, more in the anterior part which is convex. Eyestalks subcylindrical, slightly surpassing

the penultimate joint of antennal peduncle. Laminar ophthalmic scales with acute apex, the basal joint equal to the antennal peduncle. Antennal scales arise from the second joint of the peduncle, compressed and lanceolate.

Merus of cheliped with transverse wrinkles, carpus with small tubercles scattered irregularly which become spiniform near the edge. The hand and finger studded with same type of tubercles. A thick brush of long coarse hairs on the upper part of the inner surface of the right palm only. Second and third legs hardly surpass larger cheliped, outer surfaces of last four joint wrinkled and pitted. The coxa of male slightly produced ventrally.

Colour: Specimens preserved in 5% formalin has violet to purple colour.

Distribution: Indian Ocean (Borradaile 1907); Laccadives (Borradaile 1903); Philippines (Yap-Chiongco 1938); Amboina (Miers 1880); Pacific Ocean (Dana 1852; Borradaile 1898; 1900; 1907).

## Gecarcinus ruricola Stimpson 1860

Gecarcinus ruricola Stimpson 1860, p.245; 1907, p.200; Rathbun 1900, p.21; 1903, pp.8-9; Alcock 1905, p.146, pl.14, fig.1; Yap-Chiongco 1938, p.211; Barnard 1950, p.470; Pike and Serene 1956, pp.30-35, fig.3, B; fig.5, A,B,C. pl.1, 4,6 (Synonymy).

Gecarcinus violaceus Heller 1862, p.584; 1865, p.82, pl.7, fig.1; Hilgendorf 1869, p.99, pl.6, fig.3b; 1878, p.823; de Man 1888, p.255.

Gecarcinus communis Miers 1880, p.371.

Gecarcinus communissa Ortmann 1892, p.318, pl.12, fig.23, Henderson 1893, p.410; Borradaile 1899, p.425, 1901, p.97; Rathbun 1900, p.21.

Material: 10 specimens. Minicoi Island (6-3-69). 1 male, carapace length 29.5 mm; Vadalai (21-3-69) 1 male, 33.5 mm; Minicoy Island (15-2-70). 5 males, 6.5 - 12.5 mm; 3 females, 5.5 - 12.25 mm. Collected from sea shore.

Inhabits shells of Turbo sp. and Murex spp.

Description: Carapace punctate, anterior to cervical groove; lateral sides near anterior end with stiff hairs; gastric region convex. Eyestalk compressed, pitted dorsally, reaching a little short of the middle of the distal segment of antennal peduncle. Ophthalmic scalesnarrow with sharp tips. Antennular peduncle a little longer than carapace. Antennal peduncle reaching to proximal one-third of second antennular segment. Antennal scicle fused with second antennal joint.

Chelipeds have meri slightly rugulose, carpi punctate and with vesicular granules having corneous tips on the upper outer aspect. The lower outer surface of left palm smooth while right palm with spiniform granules with interspersing bristles. A thick brush of long hairs on the inner surface of the upper part of both palms. Second and third legs not reaching longer chelipeds; dark corneous tipped granules or spinules present along the upper border of the three distal segments of these legs with additional spinules scattered on the outer and inner surfaces of these segments. Dactyli of left side subtriangular, it being subcylindrical on the right side. Dactyl of third left leg flat externally; the outer surface of propodus nearly flat and not separated from the anterior surface by a crest except near the distal end. Coxae of fifth pair of legs similar in both sexes, being slightly more prominent on the left side than right.

Colour: In formalin preserved specimens ophthalmic peduncles red; antennal peduncles yellow and legs ducky red.

Distribution: Krusadai (Sundara Raj 1907); Chilka Lake (Kemp 1915); Bengal Archipelago (de Man 1888); East Indies (Rathbun 1908); Philippines (Yap-Chiongco 1938); East Africa (Hilgendorf 1869); South Africa (Barnard 1950); Viet Nam (Fize and Serene 1955).

## Cronchia ŭ pictoria Milne Edwards 1837

(Pl.XVII, 3)

Cronchia ŭ pictoria Milne Edwards 1837, p.241; de Haan 1849, p.212; Dana 1852, p.471, pl.30, fig.1; Heller 1861, p.254; 1865, p.82; de Man 1880, 0.105; 1888, p.452; Henderson 1888, p.51; 1915, p.29; Whitelegge 1897, p.140; Terao 1913, p.309; Fize and Serene 1955, pp.12-24, fig.2, A,B,C; fig. 3a; pl.I, 3,5,7-10 (Synonymy).

Cronchia ŭ pictoria Hilgendorf 1878, p.824; Ortmann 1892, p.317; pl.12, fig.22; Henderson 1893, p.410; Borradaile 1898, p.460; 1[illegible] pp. 425 ; Alcock 1905, pp.143-145, pl.14, fig.3, 3a; Southwell 1906, p.213; Yap-Chiongo 1938, p.210, pl.2, fig.7; Barnard 1950, pp.469-470, fig.86; Bachmann 1964, p.29.

Material: Several specimens. Minicoy Island (10-4-68), 6 males, carapace length, 9 to 20 mm; 5 females, 14 to 17.5 mm; (15-2-70) 1 male, 14.5 mm; 2 females, 10.5, 12 mm; Kiltan Island (27-4-39), 4 females 8 to 9 mm; Vala Tivu, Gulf of Mannar (25-2-69), 2 males, 16.5, 23.5 mm; 17 females, 13 to 18.5 mm; Manauli Island, Gulf of Mannar (6-3-68) 4 females, 13 to 18 mm; (1 berried); Andaman Island (25-4-68) 22 males, 8 to 17.5 mm; 46 females, 8 to 13.5 mm.

Occupies shells of Turbo sp. and Murex spp.

Description: Carapace granulose and punctate in front of the cervical groove. Eyestalks compressed and extend beyond middle of terminal joint of antennal peduncle. Ophthalmic scales narrow, with pointed tips. Antennular peduncle less than carapace length. Antennal peduncle reach to only middle of second antennular segment. Antennal acicle fused with second joint of peduncle.

Chelipeds unequal, left larger and massive with small vesiculose granules and setae scattered on the outer surface of hand. A stridulating ridge formed of an oblique series of laminar teeth on the upper part of the inner surface of left hand. Both palms with thick triangular brushes of long hairs on the upper inner aspect having a longitudinal ridge on the left palm, below this brush.

Coxae of 5th pair of legs slightly produced ventrally in both sexes, more so in male, especially on the left side.

Colour: Varies from yellowish brown to ash grey on the carapace and proximal segments of legs. The distal portion of the appendages light coloured. Antennular and antennal peduncle and flagella yellowish brown.

Distribution: Red Sea (Heller 1865); East Africa (Hilgendorf 1869); Seychelles and Mauritius (Richters 1880); South Africa (Krauss 1843); Indian Ocean (Milne Edwards 1837; Heller 1865); Andamans (Alcock 1905); Philippines (Yap-Chiongco 1938); Viet Nam (Fize and Serene 1955); Japan (de Haan 1850; Ortmann 1892; Terao 1913); Australia (Haswell 1882); Pacific Ocean (Dana 1852; Henderson 1888; de Man 1888).

## Coenobita perlata Milne Edwards 1837

Coenobita perlata Milne Edwards 1837, p.242; 848, pl.44, fig.1; de Haan 1849, p.213; Miers 1880, p.372; 1884, p.519, 555; Henderson 1888, p.52; Fize and Serene 1955, pp.24-30, fig.3, C. fig.4, A,B,C. pl.1, 2; Deshayes 1964, p.29.

Coenobita perlatus Richters 1880, p.160; Ortmann 1892, p.519, pl.12, fig.25; Borradaile 1898, p.459; 1899, p.397; 1901, pp.68-97; Alcock 1905, p.145, pl.15, fig.2, 2a; Lenzie 1926, p.613; Yap-Chiongco 1938, pl.211, pl.2, fig.3; Forest 1954, p.78.

Material: Several specimens. Minicoy Island (20-4-68), 26 males, carapace length 5.5 to 24.5 mm; 34 females, 5.5 to 30 mm; Kundugal (15-9-69), 1 male, 25.5 mm; 4 females, 26.5 to 34 mm (1 berried). Collected from the sea shore.

Description: Carapace with pits and granules in the cephalic region. Eyestalks compressed dorsally and laterally. Ophthalmic scales broad at base and pointed distally. Antennular peduncle less than carapace in length, reaching beyond the middle of the second segment of antennular peduncle unlike Alcock's material. Antennal scale fused with the second joint of the antennal peduncle.

Chelipeds and legs covered with small dark-tipped corneous tubercles, the corneous tips becoming more like spines on the distal segments of legs. Thick triangular brushes of long hairs present on the upper part of inner surface of both palms. The outer surface of the propodus of third left leg convex and not separated from anterior surface by a crest. Right coxa of males produced into a long curved tube.

Colours: In preserved specimens carapace, eyestalks, antennules and antennae yellowish white. Legs light yellow. Spines on dactyli of legs dark brown, tubercles white as also the setae. Brush of hairs on inner surface of palm of cheliae brown. Specimens from Minicoy Island with bright red patches across the legs near the proximal end of the segments and carapace, on the cephalic region. Antennular and antennal flagella orange. Antennal scales with red long stripe on the inner side.

Distribution: Red Sea (Nobili 1900); Laccadives (Borradaile 1901); Maldives (Borradaile 1901); East Africa (Miers 1884); Seychelles (Richters 1880); Madagascar (Lenz 1910; Bouvier 1964); Indian Ocean (Alcock 1905); Sumatra (Balss 1912); Philippines (Yap-Chiongco 1938); Pacific Ocean (Henderson 1888; Ortmann 1892; Spandler 1922; Lenzie 1926).

## GEOGRAPHIC DISTRIBUTION

The present investigation on the taxonomy of the prawns, shrimps and hermit crabs from all along the Indian coast has enabled to give a better understanding of the distribution of these decapods along the coastline of India. Although some forms have already been enjoying vide distribution in the area the intensive collections made has extended the distribution of many more species which were earlier known to have restricted distribution.

Out of the total of 31 species of penaeid prawns dealt with in the present systematic account only three species, Penaeus indicus, P. monodon and Fenneropenaeus merguiensis are found in all the areas, including Andaman and Nicobar Islands and Laccadive Archipelago (Table XI). Three species, Penaeus semisulcatus, P. semisulcatus, Metapenaeus affinis are found in all the regions except the Laccadives. Parapenaeopsis stylifera is also found to occur in all places except Laccadives and Andaman and Nicobar Islands. Many more species such as Solenocera crassicornis, S. hextii, P. japonicus, Parapenaeopsis sculptilis, Metapenaeus lysianassa, M. dobsoni, M. monoceros, M. burkenroadi, Parapenaeopsis acanthitelsonis have wider range while P. semisulcatus, Metapenaeus ensis, Fenneropenaeus penicillatus, P. indili, Parapenaeopsis uncta, P. coromandelica, P. tenella and P. sculptilentata exhibit more restricted distribution. Metapenaeus brevicornis, Parapenaeopsis maxillipedo and P. hardwickii are found only in the northern part of west and east coasts of India although M. brevicornis has been collected from Palk Bay during the present investigations. Two species viz. Metapenaeopsis acanthitelsonis, M. hilgendorfi are reported from one of the centres while Penaeopsis miniocrenata has been recorded from the type locality only.

Among the caridean prawns and shrimps only three, Palaemon tenuipes, Macrobrachium rosenbergii and Exopalaemon carinicauda enjoy very wide distribution while most of the other species collected during the present studies have restricted distribution in this region. In fact the new reports have helped to extend the distribution of some of the so called restricted species considerably in the Indo-Pacific.

Clibanarius longitarsus, Calcinus herbstii, Dardanus setifer, Aniculus striatus, Diogenes diogenes, D. custos, D. avarus, and D. investigatoris are widely distributed while Paguristes longicrenatis, Clibanarius infrapinatus, Cl. padavensis, Cl. striolatus, Cl. arethusa, Dardanus macistus, D. hessi, D. deformis, Diogenes marcianensis, D. rectimanus, Paguristes kulkarnii, Nematopagurus indicus, Spiropagurus spiriger, Coenobita cavipes and C. rugosus enjoy less wider distribution in the region. Some of the species Paguristes inconcinnatus, Calcinus latens, Clibanarius corallinus, Cl. zebra, Dardanus aspar, Diogenes costatus, Tomopagurus maccarensis, Paguristes janitor, Nematopagurus squamichelles, Coenobita syrinctus and C. perlatus are occurring in one or two regions only.

DISTRIBUTION OF DECAPOD CRUSTACEANS IN THE INDIAN COASTS

| Sl.No. | Species | NE | SE | LA | GM | PB | CC | NE | AN |
|---|---|---|---|---|---|---|---|---|---|
| 1. | *Solenocera crassicornis* | + | - | - | +* | - | + | + | - |
| 2. | *S. hextii* | + | + | - | +* | - | + | + | - |
| 3. | *Penaeus japonicus* | + | + | - | - | +* | + | + | + |
| 4. | *P. latisulcatus* | - | + | +* | +* | +* | - | - | - |
| 5. | *P. canaliculatus* | - | + | +* | - | - | - | - | +* |
| 6. | *P. semisulcatus* | + | + | - | + | + | + | + | + |
| 7. | *P. monodon* | + | + | - | + | + | + | + | + |
| 8. | *P. indicus* | + | + | + | + | + | + | + | + |
| 9. | *P. merguiensis* | + | + | + | + | + | + | + | +* |
| 10. | *Metapenaeopsis stridulans* | + | - | - | +* | +* | + | - | + |
| 11. | *M. burnsdalli* | - | - | +* | - | - | - | - | - |
| 12. | *M. bilarula* | - | - | - | +* | - | - | - | - |
| 13. | *Trachypenaeopsis miniocyensis* | - | - | +* | - | - | - | - | - |
| 14. | *Metapenaeus lysianassa* | - | + | - | +* | +* | + | + | - |
| 15. | *M. brevicornis* | + | - | - | - | +* | + | + | - |
| 16. | *M. dobsoni* | - | + | - | + | + | + | + | +* |
| 17. | *M. ensis* | - | - | - | - | - | - | + | + |
| 18. | *M. monoceros* | + | + | - | - | + | + | + | - |
| 19. | *M. affinis* | + | + | - | + | + | + | + | +* |
| 20. | *M. kutchensis* | - | + | - | + | + | + | - | +* |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 21. Trachypenaeus pescadorensis | - | + | - | +* | +* | - | - | - |
| 22. T. sedili | - | + | - | + | + | + | - | - |
| 23. T. curvirostris | + | + | +* | + | + | + | + | + |
| 24. Parapenaeopsis unata | - | + | - | + | - | + | + | - |
| 25. P. stylifera | + | + | - | + | + | + | + | - |
| 26. P. maxillipedo | + | + | - | +* | +* | + | - | - |
| 27. P. acuta | - | + | - | +* | +* | - | - | +* |
| 28. P. sculptilis | + | - | - | - | - | + | + | - |
| 29. P. hardwickii | + | - | - | - | - | - | + | - |
| 30. P. tenella | - | - | - | + | + | - | - | - |
| 31. P. acclivirostris | + | + | - | +* | - | + | + | - |
| 32. Palaemon tenuipes | + | + | - | + | - | + | + | - |
| 33. Macrobrachium rosenbergii | + | + | - | - | +* | + | + | - |
| 34. M. australe | - | - | - | - | +* | - | - | - |
| 35. M. sexdens | - | - | - | - | +* | + | - | - |
| 36. M. idella | - | + | - | - | - | + | - | - |
| 37. M. equidens | - | + | - | - | - | + | - | - |
| 38. Nematopalaemon elegans | - | - | +* | - | - | - | - | - |
| 39. Amphistylus quatos | - | - | - | + | +* | - | - | + |
| 40. Periclimenes brevicarpalis | - | - | - | + | +* | + | - | + |
| 41. Conchodytes tridentata | - | - | + | + | - | - | - | + |
| 42. Saron marmoratus | + | + | + | + | - | + | - | - |
| 43. Hippolysmata ensirostris | + | + | - | +* | - | + | - | - |
| 44. Hippolyte venticosa | - | - | - | + | +* | - | - | + |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 15. | Lutjanus pyemaeus | - | - | - | + | - | - | - | + |
| 16. | L. amoenatus | - | - | - | + | +* | - | - | + |
| 17. | Athanas dorsalis | - | - | +* | + | - | - | - | - |
| 18. | Alpheus rapax | - | - | - | - | +* | - | - | - |
| 49. | A. euphrosyne | - | - | - | +* | +* | - | - | - |
| 50. | A. distinguendus | - | - | - | +* | +* | + | - | - |
| 51. | A. malabaricus sonekia | - | +* | - | - | +* | - | - | - |
| 52. | A. crassimanus | - | - | - | + | + | - | - | + |
| 53. | Pagurosnis typica | - | + | - | - | - | - | + | - |
| 54. | Pagurietes longirostris | - | - | - | +* | +* | + | + | - |
| 55. | P. incomitatus | - | - | - | + | +* | - | - | - |
| 56. | Galeinus herbstii | - | - | + | + | + | + | + | + |
| 57. | G. oleosus | - | - | + | + | - | - | - | - |
| 58. | G. edwardsi | - | - | + | + | - | - | - | +* |
| 59. | G. latens | - | - | - | - | - | - | - | +* |
| 60. | Clibanarius infrapinatus | + | - | - | + | +* | + | - | - |
| 61. | C. padavensis | - | - | - | + | +* | + | + | - |
| 62. | C. longitarsus | - | +* | - | + | + | + | + | + |
| 63. | C. striolatus | + | - | +* | - | - | - | - | + |
| 64. | C. clibanarius | - | - | - | - | - | + | + | - |
| 65. | C. corallinus | - | - | - | - | - | - | - | + |
| 66. | C. zebra | + | - | - | +* | - | - | - | - |
| 67. | C. samaiensis | - | - | - | + | +* | - | - | - |
| 68. | C. arethusae | - | - | - | + | +* | - | + | - |
| 69. | Dardanus setifer | - | + | - | + | +* | + | + | - |
| 70. | D. arrosor | - | - | + | + | - | + | - | + |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 71. Parthenus bimaculatus | - | - | - | + | - | + | + | - |
| 72. P. deformis | - | - | + | + | - | - | - | + |
| 73. P. albus | - | - | - | + | - | - | - | + |
| 74. Agriolus striatus | - | + | - | + | + | + | + | + |
| 75. Blaesus gilvus | - | - | - | + | + | + | + | - |
| 76. P. mauritanicus | - | - | - | + | + | + | + | - |
| 77. P. dimidiatus | + | +* | - | + | - | + | + | - |
| 78. P. quatuordecimguttatus | - | - | - | + | + | + | + | + |
| 79. P. murinus | - | - | - | + | + | + | + | + |
| 80. P. costatus | - | - | - | + | +* | - | - | - |
| 81. P. rostratus | - | - | - | + | - | + | + | - |
| 82. P. inquisitorius | + | - | - | + | + | + | + | - |
| 83. Trogloscorpius madagascariensis | - | - | - | + | - | - | - | - |
| 84. Pseudolychas kulczynskii | + | - | - | +* | +* | - | - | - |
| 85. B. jupiter | - | - | - | - | - | - | - | +* |
| 86. Hemiscorpius indicus | - | + | - | - | - | + | + | - |
| 87. H. seychellensis | - | +* | - | - | - | - | - | + |
| 88. Spirobothrus spiricornis | - | - | - | +* | - | +* | + | + |

| | NW | SW | LA | GM | PB | CC | NE | AN |
|---|---|---|---|---|---|---|---|---|
| 89. Coenobita clypeatus | - | - | + | - | - | - | - | +● |
| 90. C. cavipes | - | - | + | + | - | - | + | - |
| 91. C. rugosus | - | - | +* | +* | - | - | - | +● |
| 92. C. perlatus | - | - | + | +* | - | - | - | - |

NW - Northwest coast of India

SW - Southwest coast of India

LA - Lacadive Archipelago

GM - Gulf of Mannar

PB - Palk Bay

CC - Coromandel Coast

NE - Northeast coast of India

AN - Andaman and Nicobar Islands

* New records

● New species

# PART II - BIOLOGY AND FISHERY OF *PENAEUS SEMISULCATUS*

PENAEUS SEMISULCATUS DE HAAN

## FOOD AND FEEDING HABITS

Investigations on the food and feeding habits of prawns have attracted much attention in recent years, as the growth, migration and fishery may be directly or indirectly related to the distribution and fluctuation in abundance of the organisms forming the food of these animals. Studies on this aspect of the biology of many of the commercially important species of prawns in India have been undertaken by Gopalakrishnan (1952), Pillay (1954), Menon (1951, 1953), Kunju (1955), Panikkar and Menon (1956), George (1959), Ibrahim (1962), Subramanyam (1967), Rao (1967) and Thomas (MS). The food in general is believed to consists of organic detritus mixed with sand and mud of the bottom where they feed. Besides, plant materials such as diatoms and algae and bottom living animals like gastropods, bivalves, polychaete worms and crustaceans are reported from the gut contents of these forms. The omnivorous feeding habit has been emphasised by several workers while others hold that prawns are carnivorous animals feeding mainly on a variety of small animals of the bottom of the sea.

The food and feeding habits of P.semisulcatus has not been worked out in detail previously. Hall (1962), examined the stomach contents of only 14 specimens from Singapore including some specimens from the prawn ponds.

Preliminary examinations of the stomach contents of specimens from Palk Bay and Gulf of Mannar showed marked difference in the nature and importance of the individual food items. Hence, the stomach contents of specimens from the above two areas were analysed separately.

Due to the mastication of the food inside the stomachs the items lost the individual shape and structure which made identification difficult

in most of the cases. Therefore, these food items have been grouped under broad headings such as diatoms, radiolarians, foraminiferans, polychaetes, molluscs, crustaceans, pisces. Organic matter which could not be assigned to any of the above animal or plant groups was brought under detritus. Mud and sand formed part of the stomach contents of these prawns.

Various methods are employed in the study of the food and feeding habits of fishes (Pillay 1952). Unlike fishes the quantity of the food of prawns is very little which makes it difficult to determine the actual volume by displacement method. Therefore, the points (volumetric) method (Pillay, op.cit.) was employed in the present study. Since it has been pointed out by Natarajan and Jhingran (1961) that the occurrence method or volumetric method alone will not give a correct idea of the importance of the individuals food items, both occurrence and volume are simultaneously taken into account. The analysis was done by the method of 'Index of Preponderance' as suggested by the above authors, employing the formula $\frac{VO}{\text{Sum.}VO} \times 100$, where 'V' and 'O' are percentage volume and percentage occurrence of a particular item of food respectively. The extent of the feeding was determined by the degree of distension of the stomach, and the amount of food inside the cardiac portion. The condition of food was expressed as 'gorged', 'full', 'three-fourth full', 'half-full', 'quarter-full', 'trace' and 'empty' and each is assigned 100, 80,60,40,20,10 and 0 points respectively. Depending on the relative volume of the items, points were given for each. From these values, volume for each food item was calculated. The percentage volume of each food item was found from the total volume of all the stomach contents, in each month. Similarly, the percentage occurrence of different items was determined from the total number of occurrences of all items in each month. The 'Index of Preponderance' was taken to indicate the food preferences of the prawns.

The degree of fulness of the stomach was noted against the length of the prawn to find out the condition of feed in various months. From the total numbers of prawns examined in a month the percentages of occurrence of 'gorged', 'full', 'three-fourth full', 'half-full', 'quarter-full', 'trace' and 'empty' stomachs were computed.

Qualitative and quantitative analysis.

During the course of the present study 689 stomachs of P. semisulcatus from Mandapam (Palk Bay and Gulf of Mannar) were analysed for a period of two years from April 1967 to March 1968 by the method described above. After noting the condition of feed, the cardiac portion of the stomach was cut open and the contents washed into a petri dish and examined under the microscope. The details are given in Tables I - XII.

Diatoms were invariably present in the stomach contents though in small quantities. In June, July and September they occupied third, fifth and fourth places in importance in specimens for the Palk Bay (Table III, IV and VI). The species represented are Coscinodiscus spp., Pleurosigma elongum, P. normani and P. angulatum.

Radiolarian shells were present in very small quantities during the month of May, July, August, October and March with peak occurrence in October, (Tables II, IV, V, VII and XII).

Foraminiferan shells were also less in quantity, occurring in the months of April, May, July, October and March. Globigerina bulloides, Bolivina variabilis, Quinqueloculina oblonga and Discorbis globularis were found to be present in the guts in the order of abundance. The other species encountered in the gut contents are Fissurina ventricosa, Nonion crateloufi Nonionella auricula, Quinqueloculina vulgaris, Pulvinulinella exigua and Globorotalia menardii.

TABLE I

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF

P. SEMISULCATUS

April 1967

Locality: Palk Bay — No.of prawns: 17

| Stomach contents | Percentage volume (V) | Percentage occurrence (O) | V O | $\frac{VO}{Sum\ VO} \times 100$ |
|---|---|---|---|---|
| Diatoms | 4.75 | 23.81 | 113.10 | 5.19 |
| Radiolaria | --- | --- | --- | --- |
| Foraminifera | 0.25 | 2.38 | 0.60 | 0.03 |
| Polychaetes | 11.67 | 19.05 | 222.31 | 10.20 |
| Molluscs | 5.42 | 7.14 | 38.70 | 1.78 |
| Crustacea | 8.33 | 2.38 | 19.83 | 0.91 |
| Pisces | --- | --- | --- | --- |
| Detritus | 52.50 | 28.57 | 1499.93 | 68.83 |
| Sand and mud | 17.08 | 16.67 | 284.72 | 13.06 |
| Total | 100.00 | 100.00 | 2179.19 | 100.00 |

TABLE II

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF

P. SEMISCULCATUS

May 1967

Locality: Palk Bay — No. of prawns: 26

| Stomach contents | Percentage volume (V) | Percentage occurrence (O) | V O | $\frac{VO}{Sum.VO} \times 100$ |
|---|---|---|---|---|
| Diatoms | 2.81 | 19.28 | 54.18 | 2.76 |
| Radiolaria | 0.14 | 1.21 | 0.17 | 0.01 |
| Foraminifera | 0.10 | 1.20 | 0.12 | 0.01 |
| Polychaetes | 3.76 | 14.46 | 54.37 | 2.77 |
| Molluscs | 4.76 | 3.61 | 17.18 | 0.87 |
| Crustacea | 11.52 | 10.84 | 124.88 | 6.36 |
| Pisces | 5.48 | 3.61 | 19.78 | 1.01 |
| Detritus | 59.76 | 24.10 | 1440.22 | 73.33 |
| Sand and mud | 11.67 | 21.69 | 253.12 | 12.88 |
| Total | 100.00 | 100.00 | 1964.02 | 100.00 |

TABLE III

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF

P. SEMISULCATUS

June 1967

Locality: Palk Bay — No.of prawns: 21

| Stomach contents | Percentage volume (V) | Percentage occurrence (O) | V O | $\frac{VO}{Sum.VO} \times 100$ |
|---|---|---|---|---|
| Diatoms | 5.38 | 23.21 | 24.87 | 5.80 |
| Radiolaria | --- | --- | --- | --- |
| Foraminifera | --- | --- | --- | --- |
| Polychaetes | 5.54 | 21.43 | 118.72 | 5.52 |
| Molluscs | 4.23 | 1.79 | 7.57 | 0.35 |
| Crustacea | 4.23 | 7.15 | 30.24 | 1.40 |
| Pisces | --- | --- | --- | --- |
| Detritus | 68.85 | 23.21 | 1598.01 | 74.24 |
| Sand and mud | 11.77 | 23.21 | 273.18 | 12.69 |
| Total | 100.00 | 100.00 | 2152.59 | 100.00 |

TABLE IV

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF

P. SEMISULCATUS

- July 1967

Locality: Palk Bay — No.of prawns: 29

| Stomach contents | Percentage volume (V) | Percentage occurrence (O) | V O | $\frac{VO}{Sum.VO} \times 100$ |
|---|---|---|---|---|
| Diatoms | 5.35 | 17.53 | 93.79 | 5.95 |
| Radiolaria | 3.10 | 5.16 | 16.00 | 1.02 |
| Foraminifera | 0.25 | 1.03 | 0.26 | 0.02 |
| Polychaetes | 21.55 | 16.49 | 355.36 | 22.57 |
| Molluscs | 7.75 | 5.15 | 39.91 | 2.54 |
| Crustacea | 12.50 | 11.34 | 141.75 | 9.01 |
| Pisces | 2.50 | 5.15 | 12.87 | 0.82 |
| Detritus | 40.50 | 19.59 | 793.40 | 50.41 |
| Sand and mud | 6.50 | 18.56 | 120.64 | 7.66 |
| Total | 100.00 | 100.00 | 1573.98 | 100.00 |

TABLE V

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF

P. SEMISULCATUS

August 1967

Locality: Palk Bay

No.of prawns: 28

| Stomach contents | Percentage volume (V) | Percentage occurrence (O) | V O | $\frac{VO}{Sum.VO} \times 100$ |
|---|---|---|---|---|
| Diatoms | 2.78 | 9.45 | 26.27 | 1.63 |
| Radiolaria | 0.11 | 0.79 | 0.09 | 0.01 |
| Foraminifera | --- | --- | --- | --- |
| Polychaetes | 12.67 | 14.96 | 189.54 | 11.79 |
| Molluscs | 19.18 | 13.39 | 265.26 | 16.49 |
| Crustacea | 11.11 | 15.75 | 174.98 | 10.88 |
| Pisces | 10.74 | 7.87 | 84.52 | 5.25 |
| Detritus | 33.89 | 21.26 | 720.50 | 44.80 |
| Sand and mud | 8.89 | 16.53 | 146.96 | 9.14 |
| Total | 100.00 | 100.00 | 1608.12 | 100.00 |

TABLE VI

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF

*P. SEMISULCATUS*

September 1967

Locality: Palk Bay  No.of prawns: 34

| Stomach contents | Percentage volume (V) | Percentage occurrence (O) | V O | $\frac{VO}{Sum.VO} \times 100$ |
|---|---|---|---|---|
| Diatoms | 6.13 | 19.81 | 121.44 | 7.07 |
| Radiolaria | --- | --- | --- | --- |
| Foraminifera | --- | --- | --- | --- |
| Polychaetes | 6.91 | 13.21 | 91.28 | 5.31 |
| Molluscs | 18.35 | 10.38 | 190.47 | 11.01 |
| Crustacea | 11.30 | 12.26 | 138.54 | 8.06 |
| Pisces | 2.74 | 4.72 | 12.93 | 0.75 |
| Detritus | 49.00 | 21.70 | 1063.30 | 61.91 |
| Sand and mud | 5.57 | 17.92 | 99.81 | 5.81 |
| Total | 100.00 | 100.00 | 1717.77 | 100.00 |

TABLE VII

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF

P. SEMISULCATUS

October 1967

Locality: Palk Bay — No.of prawns: 27

| Stomach contents | Percentage volume (V) | Percentage occurrence (O) | V O | $\frac{VO}{Sum.VO} \times 100$ |
|---|---|---|---|---|
| Diatoms | 1.41 | 6.90 | 9.73 | 0.66 |
| Radiolaria | 12.94 | 11.49 | 148.68 | 10.06 |
| Foraminifera | 0.59 | 1.15 | 0.68 | 0.05 |
| Polychaetes | 19.00 | 14.94 | 283.86 | 19.20 |
| Molluscs | 6.47 | 9.20 | 59.71 | 4.03 |
| Crustacea | 18.65 | 14.94 | 278.64 | 18.86 |
| Pisces | 4.59 | 3.45 | 15.84 | 1.07 |
| Detritus | 25.47 | 18.39 | 468.39 | 31.69 |
| Sand and mud | 10.88 | 19.54 | 212.60 | 14.38 |
| Total | 100.00 | 100.00 | 1478.13 | 100.00 |

TABLE VIII

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF

*P. SEMISULCATUS*

November 1967

Locality: Gulf of Mannar — No.of prawns: 30

| Stomach contents | Percentage volume (V) | Percentage occurrence (O) | V O | $\frac{VO}{Sum.VO} \times 100$ |
|---|---|---|---|---|
| Diatoms | 7.89 | 17.72 | 139.81 | 8.87 |
| Radiolaria | 14.54 | 12.03 | 175.92 | 11.17 |
| Foraminifera | 1.04 | 5.06 | 5.26 | 0.33 |
| Polychaetes | 10.57 | 15.19 | 160.56 | 10.19 |
| Molluscs | 18.68 | 17.09 | 319.24 | 20.26 |
| Crustacea | 18.96 | 14.56 | 276.06 | 17.52 |
| Pisces | --- | --- | --- | --- |
| Detritus | 28.14 | 17.72 | 498.64 | 31.65 |
| Sand and mud | 0.18 | 0.63 | 0.11 | 0.01 |
| Total | 100.00 | 100.00 | 1575.60 | 100.00 |

TABLE IX

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF

P. SEMISULCATUS

December 1967

Locality: Gulf of Mannar — No.of prawns: 31

| Stomach contents | Percentage volume (V) | Percentage occurrence (O) | V O | $\frac{VO}{Sum.VO} \times 100$ |
|---|---|---|---|---|
| Diatoms | 0.73 | 2.02 | 1.47 | 0.08 |
| Radiolaria | 7.17 | 7.38 | 52.91 | 2.92 |
| Foraminifera | 0.17 | 2.02 | 0.34 | 0.02 |
| Polychaetes | 4.47 | 12.08 | 54.00 | 2.98 |
| Molluscs | 38.93 | 20.13 | 783.66 | 43.25 |
| Crustacea | 18.60 | 19.46 | 361.96 | 19.98 |
| Pisces | --- | --- | --- | --- |
| Detritus | 22.73 | 18.79 | 427.10 | 23.57 |
| Sand and mud | 7.20 | 18.12 | 130.46 | 7.20 |
| Total | 100.00 | 100.00 | 1811.90 | 100.00 |

TABLE X

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF

P. SEMISULCATUS

January 1968

Locality: Gulf of Mannar  No.of prawns: 20

| Stomach contents | Percentage volume (V) | Percentage occurrence (O) | V O | $\frac{VO}{Sum.VO} \times 100$ |
|---|---|---|---|---|
| Diatoms | --- | --- | --- | --- |
| Radiolaria | 6.05 | 8.82 | 53.36 | 3.03 |
| Foraminifera | 0.45 | 2.94 | 1.32 | 0.08 |
| Polychaetes | 15.00 | 18.63 | 279.45 | 15.88 |
| Molluscs | 42.10 | 19.61 | 825.58 | 46.93 |
| Crustacea | 13.90 | 17.65 | 245.34 | 13.95 |
| Pisces | 0.10 | 0.98 | 0.10 | 0.01 |
| Detritus | 9.90 | 14.71 | 145.63 | 8.28 |
| Sand and mud | 12.50 | 16.66 | 208.25 | 11.84 |
| Total | 100.00 | 100.00 | 1759.04 | 100.00 |

TABLE XI

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF

P. SEMISULCATUS

February 1968

Locality: Gulf of Mannar — No.of prawns: 25

| Stomach contents | Percentage volume (V) | Percentage occurrence (O) | V O | $\frac{VO}{Sum.VO} \times 100$ |
|---|---|---|---|---|
| Diatoms | 1.59 | 11.11 | 17.66 | 1.02 |
| Radiolaria | --- | --- | --- | --- |
| Foraminifera | 0.36 | 3.03 | 1.09 | 0.06 |
| Polychaetes | 26.00 | 20.21 | 525.46 | 30.29 |
| Molluscs | 16.23 | 13.13 | 213.10 | 12.28 |
| Crustacea | 18.64 | 15.15 | 282.40 | 16.28 |
| Pisces | 1.91 | 3.03 | 5.79 | 0.33 |
| Detritus | 28.00 | 21.21 | 593.88 | 34.23 |
| Sand and mud | 7.27 | 13.13 | 96.46 | 5.51 |
| Total | 100.00. | 100.00 | 1734.84 | 100.00 |

TABLE XII

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF

P. SEMISULCATUS

March 1968

Locality: Palk Bay — No.of prawns: 34

| Stomach contents | Percentage volume (V) | Percentage occurrence (O) | V O | $\frac{VO}{Sum.VO}$ x 100 |
|---|---|---|---|---|
| Diatoms | 1.71 | 9.52 | 16.28 | 0.90 |
| Radiolaria | 3.23 | 8.16 | 26.36 | 1.45 |
| Foraminifera | 0.16 | 1.36 | 0.35 | 0.02 |
| Polychaetes | 18.71 | 20.41 | 381.87 | 21.02 |
| Molluscs | 35.97 | 18.37 | 660.77 | 36.38 |
| Crustacea | 23.55 | 19.05 | 448.63 | 24.69 |
| Pisces | --- | --- | --- | --- |
| Detritus | 14.00 | 18.37 | 273.71 | 15.08 |
| Sand and mud | 1.77 | 4.76 | 8.43 | 0.46 |
| Total | 100.00 | 100.00 | 1816.40 | 100.00 |

Polychaete worms formed an important item of the food of these prawns. They were present in good quantities in all months, ranking second in July and October, third in April August and March, fourth in May and June and sixth in September. Due to the soft body these worms were crushed into a pulp-like mass with setae embedded in it. Hence the identity of these could not be fixed.

Molluscs also were one of the regular food items of this species. These were mostly young lamellibranchs. Although crushed shells of various forms only were observed the fresh appearance of these shells indicated that they might have been alive when they were ingested and the soft parts subsequently digested and absorbed. Gastropod shells of smaller sizes were also encountered in the stomach contents though less numerous. Molluscan item ranked first during March while it was second in August and September. In other months they were less abundant, occupying only fifth, sixth and seventh places in the order of abundance.

Crustaceans formed in important constituent of the dietary components of P.semisulcatus, ranking second in March 1968, third in May, July, September and October 1967. In June and April this formed only fifth and sixth respectively in the order of abundance. The crustacean item included portion of the penaeid prawns, mysids and isopods. Free living copepods probably belonging to Calanoidea were found occasionally in the stomachs. From the nature of the decapod remains in the stomach it seems quite likely that these prawns may eat the exuviae of juvenile prawns along with the bottom mud. However, in many instances portions of these crustaceans were found in fresh as wellas semidigested condition. As this item is almost always present in the stomachs it is certain that this forms a regular food item of the species throughout the year.

Pisces were less important as food of P. semisulcatus. This item was present in the guts in the form of skeletal structures like bones, vertebrae and scales. In an few instances crystalline lenses of the eyes were found in tact which indicated that the entire animal was eaten. This item occupied sixth place during May and August while it was seventh in September and October and eighth in July. Fish was not present in the stomachs examined in April and June 1967 and March 1968 (Table XIII).

Detritus was found in heavy concentration during all the months. It ranked first in importance among the food items of this species in the months of April to October, 1967, while it was only fourth in March 1968. The presence of large quantities of detritus in the stomachs may be due to the bottom feeding habit of these prawns coupled with the thorough mastication to which the food is subjected during feeding.

Mud and sand were also found in all the months. These items which are actually accidental inclusions during the feeding at the bottom were predominent in April, May and June. In July and October these occupied only fourth rank while they were fifth in August and September and seventh in March 1968.

Although mud does not have much nutritive value it may be one of the sources for the organic and mineral substances, required by the prawns. The sand grains may assist in the complete mastication of the food.

In a few instances spicules of the sponge Tedania nigricans (Schmidt) and anchor plates of holothurian echinoderms were also found in the stomachs. Since the quantity was negligible these items were not taken into account.

ANALYSED BY THE METHOD OF INDEX OF PREPONDERANCE

Palk Bay

1967 - 1968

| | Apr. 1967 | May 1967 | Jun. 1967 | Jul. 1967 | Aug. 1967 | Sep. 1967 | Oct. 1967 | Nov. 1968 |
|---|---|---|---|---|---|---|---|---|
| Number of genera | 17 | 26 | 21 | 29 | 28 | 34 | 27 | 34 |
| Diatoms | 4 | 5 | 3 | 5 | 7 | 4 | 8 | 6 |
| Radiolaria | - | 8 | - | 7 | 8 | - | 5 | 5 |
| Foraminifera | 7 | 8 | - | 9 | - | - | 9 | 8 |
| Polychaetes | 3 | 4 | 4 | 2 | 3 | 6 | 2 | 3 |
| Molluscs | 5 | 7 | 6 | 6 | 2 | 2 | 6 | 1 |
| Crustacea | 6 | 3 | 5 | 3 | 4 | 3 | 3 | 2 |
| Pisces | - | 6 | - | 8 | 6 | 7 | 7 | - |
| Detritus | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 4 |
| Sand and mud | 2 | 2 | 2 | 4 | 5 | 5 | 4 | 7 |

The composition of the food and abundance of the individual items varied considerably between stomach contents of specimens examined from the Palk Bay and Gulf of Mannar. This may be due to the difference in the nature of the sea bottom. In Palk Bay the bottom is either sandy or muddy or sandy with soft mud while in the Gulf of Mannar the bottom is mostly rocky in the shallow areas, due to the presence of the coral reefs around the numerous small islands situated not far from the shore. The percentage volumes of food items in the stomachs of P. semisulcatus during 1967-1968 are given in Table XIV.

Diatoms were of the same importance in specimens from Gulf of Mannar as in Prawns examined from Palk Bay. They were absent during January 1968.

Radiolarians occurred in large quantities ranking fourth and sixth although it was not represented in the month of February 1968 Table XV.

The stomach content of prawns collected from the Gulf of Mannar contained foraminiferans in all the months while this food item was less abundant in specimens from Palk Bay.

The presentage volume of polychaetes remained the same in the food of specimens from the Gulf of Mannar, ranking second in January and February, 1968 and fifth in November and December, 1967 Table XVI.

The bulk of the stomach contents from the Gulf of Mannar consisted of molluscs ranking first in December and January second in November and fourth in February 1968. This item was more abundant in specimens from this locality.

TABLE XIV

PERCENTAGE VOLUME OF FOOD ITEMS PRESENT IN THE STOMACH CONTENTS OF

*P. SEMISULCATUS*

Palk Bay

1967 - 1968

| | Apr. 1967 | May 1967 | Jun. 1967 | Jul. 1967 | Aug. 1967 | Sep. 1967 | Oct. 1967 | Mar. 1968 |
|---|---|---|---|---|---|---|---|---|
| Number of prawns | 17 | 26 | 21 | 29 | 28 | 34 | 27 | 34 |
| Diatoms | 4.75 | 2.81 | 5.38 | 5.35 | 2.78 | 6.15 | 1.41 | 1.71 |
| Radiolaria | -- | 0.14 | -- | 3.10 | 0.11 | -- | 12.94 | 3.23 |
| Foraminifera | 0.25 | 0.10 | -- | 0.25 | -- | -- | 0.59 | 0.16 |
| Polychaetes | 11.67 | 3.76 | 5.54 | 21.55 | 12.67 | 6.91 | 19.00 | 18.71 |
| Molluscs | 5.42 | 4.76 | 4.23 | 7.75 | 19.81 | 18.35 | 6.47 | 35.97 |
| Crustacea | 8.33 | 11.52 | 4.23 | 12.50 | 11.11 | 11.30 | 18.65 | 23.55 |
| Pisces | -- | 5.48 | -- | 2.50 | 10.74 | 2.74 | 4.59 | -- |
| Detritus | 52.50 | 69.76 | 68.85 | 40.50 | 33.89 | 49.00 | 25.47 | 14.90 |
| Sand and mud | 17.08 | 11.67 | 11.77 | 6.50 | 8.89 | 5.57 | 10.88 | 1.77 |

ANALYSED BY THE METHOD OF INDEX OF PREPONDERANCE

Gulf of Manner

1967 - 1969

| | Nov. 1967 | Dec. 1967 | Jan. 1968 | Feb. 1968 | Dec. 1968 | Jan. 1969 | Feb. 1969 | Mar. 1969 |
|---|---|---|---|---|---|---|---|---|
| Number of prawns | 30 | 31 | 20 | 25 | 33 | 33 | 33 | 33 |
| Diatoms | 6 | 7 | - | 6 | - | - | - | - |
| Radiolaria | 4 | 6 | 6 | - | 6 | 6 | 6 | 6 |
| Foraminifera | 7 | 8 | 7 | 8 | 7 | 7 | - | - |
| Polychaetes | 5 | 5 | 2 | 2 | 3 | 2 | 3 | 3 |
| Molluscs | 2 | 1 | 1 | 4 | 1 | 1 | 1 | 1 |
| Crustacea | 3 | 3 | 3 | 3 | 2 | 3 | 2 | 2 |
| Pisces | - | - | 8 | 7 | - | - | 7 | - |
| Detritus | 1 | 2 | 5 | 1 | 5 | 4 | 4 | 5 |
| Sand and mud | 8 | 4 | 4 | 5 | 4 | 5 | 5 | 4 |

PERCENTAGE VOLUME OF FOOD ITEMS PRESENT IN THE STOMACH CONTENTS

OF *P. SEMISULCATUS*

Gulf of Mannar

1967 - 1969

| | Nov. 1967 | Dec. 1967 | Jan. 1968 | Feb. 1968 | Dec. 1968 | Jan. 1969 | Feb. 1969 | Mar. 1969 |
|---|---|---|---|---|---|---|---|---|
| No.of prawns | 30 | 31 | 20 | 25 | 33 | 33 | 33 | 33 |
| Diatoms | 7.89 | 0.73 | --- | 1.59 | --- | --- | --- | --- |
| Radiolaria | 14.54 | 7.17 | 6.05 | --- | 8.73 | 5.59 | 1.08 | 1.88 |
| Foraminifera | 1.04 | 0.17 | 0.45 | 0.36 | 0.33 | 0.09 | --- | --- |
| Polychaetes | 10.57 | 4.47 | 15.00 | 26.00 | 13.57 | 22.88 | 15.50 | 17.56 |
| Molluscs | 18.68 | 38.93 | 32.10 | 16.23 | 28.17 | 29.84 | 32.31 | 39.69 |
| Crustacea | 18.96 | 18.60 | 13.90 | 18.64 | 25.27 | 21.56 | 28.85 | 20.56 |
| Pisces | --- | --- | 0.10 | 1.91 | --- | --- | 0.69 | --- |
| Detritus | 28.14 | 22.73 | 9.90 | 28.00 | 10.77 | 10.66 | 12.69 | 9.28 |
| Sand and mud | 0.18 | 7.20 | 12.50 | 7.27 | 13.16 | 9.38 | 7.88 | 10.03 |

The quantity of crustaceans in the food of prawns from the Gulf of Mannar was more as this item kept up the third rank in four months ofthe year.

The presentage of fish material in this stomach was less in stomachs from Gulf of Mannar.

The detritus also was less in important in the food of prawns from the Gulf of Mannar being first in abundance only in November and February, second in December and fifth in January 1968.

Mud and sand were found in less magnitude in the stomachs examined from the Gulf, probably due to the hard bottom in most of the fishing grounds.

The stomach contents of prawns collected from Mandapam landing centres from the Palk Bay and Gulf of Mannar were analysed during the year 1968-1969 and the details presented in Tables XVII-XXVIII.

There was no appreciable change in the general pattern of occurrence of diatoms in the food during the second year.

Radiolarians formed part of the food items only during April to July 1968, occupying the last ranks.

During October-November foraminiferans were not present in the stomachs while in the rest of the period they occurred in meagre quantities.

Polychaetes ranked third in April, fourth in May, June and August, fifth in November while this item was only sixth in September and October and seventh in July in the order of abundance (Table XXIX).

TABLE XVII

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF

P. SEMISULCATUS

April 1968

Locality: Palk Bay

T No.of prawns:34

| Stomach contents | Percentage volume (V) | Percentage occurrence (O) | V O | $\frac{VO}{Sum.VO} \times 100$ |
|---|---|---|---|---|
| Diatoms | 1.28 | 8.84 | 11.32 | 0.67 |
| Radiolaria | 2.59 | 6.80 | 17.61 | 1.04 |
| Foraminifera | 0.34 | 1.36 | 0.46 | 0.03 |
| Polychaetes | 21.24 | 17.01 | 361.29 | 21.26 |
| Molluscs | 28.48 | 17.69 | 503.81 | 29.65 |
| Crustacea | 25.00 | 18.37 | 459.25 | 27.03 |
| Fishes | --- | --- | --- | --- |
| Detritus | 16.03 | 17.69 | 283.57 | 16.69 |
| Sand and mud | 5.04 | 12.24 | 61.69 | 3.63 |
| Total | 100.00 | 100.00 | 1699.00 | 100.00 |

TABLE XVIII

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF

P. SEMISULCATUS

May 1968

Locality: Palk Bay — No. of prawns: 32

| Stomach contents | Percentage volume (V) | Percentage occurrence (O) | V O | $\frac{VO}{Sum.VO} \times 100$ |
|---|---|---|---|---|
| Diatoms | 1.17 | 6.12 | 7.16 | 0.52 |
| Radiolaria | 2.78 | 9.18 | 25.52 | 1.84 |
| Foraminifera | 0.89 | 5.10 | 4.54 | 0.33 |
| Flychaetes | 11.94 | 16.33 | 194.98 | 14.06 |
| Molluscs | 22.78 | 14.29 | 325.53 | 23.47 |
| Crustacea | 15.55 | 16.33 | 253.93 | 18.31 |
| Pisces | 11.67 | 3.06 | 35.71 | 2.57 |
| Detritus | 26.00 | 17.35 | 451.10 | 32.53 |
| Sand and mud | 7.22 | 12.24 | 88.37 | 6.37 |
| Total | 100.00 | 100.00 | 1386.84 | 100.00 |

TABLE XIX

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF

P. SEMISULCATUS

June 1968

Locality: Palk Bay

No.of prawns: 34

| Stomach contents | Percentage volume (V) | Percentage occurrence (O) | V O | $\frac{VO}{Sum.VO} \times 100$ |
|---|---|---|---|---|
| Diatoms | 1.27 | 9.83 | 12.48 | 0.89 |
| Radiolaria | 1.93 | 4.62 | 8.92 | 0.64 |
| Foraminifera | 0.45 | 2.89 | 1.30 | 0.09 |
| Polychaetes | 9.66 | 14.45 | 139.59 | 9.89 |
| Molluscs | 24.34 | 12.72 | 309.60 | 21.94 |
| Crustacea | 11.14 | 12.14 | 135.24 | 9.58 |
| Pisces | 7.83 | 9.83 | 76.97 | 5.45 |
| Detritus | 30.45 | 16.76 | 510.34 | 36.16 |
| Sand and mud | 12.93 | 16.76 | 216.71 | 15.36 |
| Total | 100.00 | 100.00 | 1411.15 | 100.00 |

TABLE XX

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF

P. SEMISULCATUS

July 1968

Locality: Palk Bay  No.of prawns: 30

| Stomach contents | Percentage volume (V) | Percentage occurrence (O) | V O | $\frac{VO}{Sum.VO} \times 100$ |
|---|---|---|---|---|
| Diatoms | 1.32 | 12.94 | 17.08 | 0.91 |
| Radiolaria | 0.42 | 1.17 | 0.49 | 0.03 |
| Foraminifera | 0.11 | 1.18 | 0.13 | 0.01 |
| Polychaetes | 1.84 | 4.71 | 8.67 | 0.46 |
| Molluscs | 20.16 | 14.12 | 284.66 | 15.24 |
| Crustacea | 5.53 | 10.59 | 58.56 | 3.14 |
| Pisces | 6.52 | 11.76 | 76.68 | 4.11 |
| Detritus | 54.21 | 22.35 | 1211.59 | 64.88 |
| Sand and mud | 9.89 | 21.18 | 209.47 | 11.22 |
| Total | 100.00 | 100.00 | 1867.33 | 100.00 |

TABLE XXI

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF

P. SEMISULCATUS

August 1968

Locality: Palk Bay — No.of prawns: 26

| Stomach contents | Percentage volume (V) | Percentage occurrence (O) | V O | $\frac{VO}{Sum.VO} \times 100$ |
|---|---|---|---|---|
| Diatoms | 1.36 | 16.47 | 22.40 | 1.07 |
| Radiolaria | --- | --- | --- | --- |
| Foraminifera | 0.14 | 1.18 | 0.17 | 0.01 |
| Polychaetes | 5.68 | 10.59 | 60.15 | 2.87 |
| Molluscs | 15.56 | 11.76 | 182.99 | 8.77 |
| Crustacea | 7.86 | 7.06 | 55.49 | 2.66 |
| Pisces | 0.68 | 2.35 | 1.60 | 0.08 |
| Detritus | 57.77 | 25.88 | 1495.09 | 71.58 |
| Sand and mud | 10.35 | 24.71 | 270.57 | 12.96 |
| Total | 100.00 | 100.00 | 2088.46 | 100.00 |

TABLE XXII

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF

P. SEMISULCATUS

September 1968

Locality: Palk Bay — No.of prawns: 30

| Stomach contents | Percentage volume (V) | Percentage occurrence (O) | V O | $\frac{VO}{\text{Sum.VO}} \times 100$ |
|---|---|---|---|---|
| Diatoms | 2.38 | 24.18 | 57.55 | 2.61 |
| Radiolaria | --- | --- | --- | --- |
| Foraminifera | 0.08 | 1.10 | 0.09 | 0.01 |
| Polychaetes | 2.00 | 4.40 | 8.80 | 0.40 |
| Molluscs | 17.29 | 12.09 | 209.04 | 9.48 |
| Crustacea | 6.46 | 5.49 | 35.47 | 1.61 |
| Fishes | --- | --- | --- | --- |
| Detritus | 60.96 | 26.37 | 1607.52 | 72.93 |
| Sand and mud | 10.83 | 26.37 | 285.59 | 12.96 |
| Total | 100.00 | 100.00 | 2204.06 | 100.00 |

TABLE XXIII

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF

P. SEMISULCATUS

October 1968

Locality: Palk Bay

No.of prawns: 32

| Stomach contents | Percentage volume (V) | Percentage occurrence (O) | V O | $\frac{VO}{Sum.VO} \times 100$ |
|---|---|---|---|---|
| Diatoms | 0.61 | 8.33 | 5.08 | 0.24 |
| Radiolaria | --- | --- | --- | --- |
| Foraminifera | --- | --- | --- | --- |
| Polychaetes | 2.39 | 5.00 | 11.95 | 0.56 |
| Molluscs | 16.94 | 11.68 | 197.86 | 9.32 |
| Crustacea | 8.89 | 10.00 | 88.90 | 4.18 |
| Pisces | 9.72 | 8.33 | 80.97 | 3.81 |
| Detritus | 52.00 | 28.33 | 1473.16 | 69.30 |
| Sand and mud | 9.45 | 28.33 | 267.72 | 12.59 |
| Total | 100.00 | 100.00 | 2125.64 | 100.00 |

TABLE XXIV

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF

*P. SEMISULCATUS*

November 1968

Locality: Palk Bay — No.of prawns: 17

| Stomach contents | Percentage volume (V) | Percentage occurrence (O) | V O | $\frac{VO}{Sum.VO} \times 100$ |
|---|---|---|---|---|
| Diatoms | --- | --- | --- | --- |
| Radiolaria | --- | --- | --- | --- |
| Foraminifera | --- | --- | --- | --- |
| Polychaetes | 0.50 | 3.57 | 1.79 | 0.06 |
| Molluscs | 6.00 | 10.70 | 64.20 | 2.00 |
| Crustacea | 9.50 | 14.29 | 135.76 | 4.24 |
| Pisces | --- | --- | --- | --- |
| Detritus | 64.50 | 35.72 | 2303.94 | 71.95 |
| Sand and mud | 19.50 | 35.72 | 696.54 | 21.75 |
| Total | 100.00 | 100.00 | 3202.33 | 100.00 |

TABLE XXV

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF

P. SEMISULCATUS

December 1968

Locality: Gulf of Mannar  No.of prawns: 33

| Stomach contents | Percentage volume (V) | Percentage occurrence (O) | V O | $\frac{VO}{Sum.VO} \times 100$ |
|---|---|---|---|---|
| Diatoms | --- | --- | --- | --- |
| Radiolaria | 8.73 | 11.93 | 104.15 | 6.15 |
| Foraminifera | 0.33 | 1.14 | 0.38 | 0.02 |
| Polychaetes | 13.57 | 17.61 | 238.97 | 14.12 |
| Molluscs | 28.17 | 17.61 | 496.00 | 29.31 |
| Crustacea | 25.27 | 17.61 | 445.00 | 26.29 |
| Pisces | --- | --- | --- | --- |
| Detritus | 10.77 | 17.05 | 183.63 | 10.85 |
| Sand and mud | 13.16 | 17.05 | 224.38 | 13.26 |
| Total | 100.00 | 100.00 | 1692.58 | 100.00 |

TABLE XXVI

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF

P. SEMISULCATUS

January 1969

Locality: Gulf of Mannar  No.of prawns: 33

| Stomach contents | Percentage volume (V) | Percentage occurrence (O) | V O | $\frac{VO}{Sum.VO} \times 100$ |
|---|---|---|---|---|
| Diatoms | --- | --- | --- | --- |
| Radiolaria | 5.59 | 11.17 | 62.44 | 3.59 |
| Foraminifera | 0.09 | 0.55 | 0.05 | 0.01 |
| Polychaetes | 22.88 | 17.88 | 409.04 | 23.54 |
| Molluscs | 29.84 | 17.88 | 533.54 | 30.72 |
| Crustacea | 21.56 | 17.88 | 385.49 | 22.19 |
| Pisces | --- | --- | --- | --- |
| Detritus | 10.66 | 16.76 | 178.66 | 10.29 |
| Sand and mud | 9.38 | 17.88 | 167.71 | 9.66 |
| Total | 100.00 | 100.00 | 1736.98 | 100.00 |

TABLE XXVII

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF

P. SEMISULCATUS

Feburary 1969

Locality: Gulf of Mannar

No.of prawns: 33

| Stomach contents | Percentage volume (V) | Percentage occurrence (O) | V O | $\frac{VO}{Sum.VO} \times 100$ |
|---|---|---|---|---|
| Diatoms | --- | --- | --- | --- |
| Radiolaria | 1.08 | 5.92 | 6.39 | 0.35 |
| Foraminifera | --- | --- | --- | --- |
| Polychaetes | 16.50 | 17.04 | 281.16 | 15.34 |
| Molluscs | 32.31 | 19.26 | 622.29 | 33.94 |
| Crustacea | 28.85 | 19.26 | 555.25 | 30.31 |
| Pisces | 0.69 | 2.96 | 2.04 | 0.11 |
| Detritus | 12.69 | 17.78 | 225.63 | 12.31 |
| Sand and mud | 7.88 | 17.78 | 140.11 | 7.64 |
| Total | 100.00 | 100.00 | 1835.27 | 100.00 |

TABLE XXVIII

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF

P. SEMISULCATUS

March 1969

Locality: Gulf of Mannar  No.of prawns: 33

| Stomach contents | Percentage volume (V) | Percentage occurrence (O) | V O | $\frac{VO}{Sum.VO} \times 100$ |
|---|---|---|---|---|
| Diatoms | --- | --- | --- | --- |
| Radiolaria | 1.88 | 8.59 | 16.15 | 0.88 |
| Foreminifera | --- | --- | --- | --- |
| Polychaetes | 17.56 | 17.18 | 301.68 | 16.38 |
| Molluscs | 39.69 | 19.63 | 779.11 | 42.29 |
| Crustacea | 20.56 | 18.40 | 378.30 | 20.53 |
| Pisces | --- | --- | --- | --- |
| Detritus | 9.28 | 18.40 | 170.75 | 9.26 |
| Sand and mud | 11.03 | 17.80 | 196.33 | 10.66 |
| Total | 100.00 | 100.00 | 1842.32 | 100.00 |

TABLE XXIX

THE MARKS OBTAINED BY VARIOUS ITEMS OF FOOD OF *P. SEMISULCATUS* AS ANALYSED BY THE METHOD OF INDEX OF PREPONDERANCE

Palk Bay

1968

| No.of prawns | Apr. 34 | May 32 | Jun. 34 | Jul. 30 | Aug. 26 | Sep. 30 | Oct. 32 | Nov. 17 |
|---|---|---|---|---|---|---|---|---|
| Diatoms | 7 | 8 | 7 | 6 | 7 | 4 | 7 | - |
| Radiolaria | 6 | 7 | 8 | 8 | - | - | - | - |
| Foraminifera | 8 | 9 | 9 | 9 | 8 | 7 | - | - |
| Polychaetes | 3 | 4 | 4 | 7 | 4 | 6 | 6 | 5 |
| Molluscs | 1 | 2 | 2 | 2 | 3 | 3 | 3 | 4 |
| Crustacea | 2 | 3 | 5 | 5 | 5 | 5 | 4 | 3 |
| Pisces | - | 6 | 6 | 4 | 6 | - | 5 | - |
| Detritus | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Sand and mud | 5 | 5 | 3 | 3 | 2 | 2 | 2 | 2 |

Molluscan material in the food of the species registered higher percentages during the various months of the year 1968-1969. This item occupied first to fourth places in the order of importance during these months as against the previous year.

In the stomach contents of the species, crustaceans dominated, more or less in the same degree as in the previous year ranking second to fifth in abundance.

Pisces were absent in three months as in the previous year, though the rank they occupied improved from eight to fourth and sixth.

Detritus was as abundant as in the previous year, being first in all the months except in April. The percentage volume in various months is given in Table XXX.

Mud and sand also registered increase in quantity in the stomachs during the second year.

During the year 1968-'69 diatoms were not represented in the food of these prawns from the Gulf of Mannar.

Radiolarians ranked sixth in all the four months when samples were examined from the Gulf of Mannar.

The stomach contents of February and March 1969 did not contain foraminiferans.

Polychaetes remained an important food item during the second year, occupying second and third places.

But during this period Molluscan item was in abundance ranking first in all the months.

PERCENTAGE VOLUME OF FOOD ITEMS PRESENT IN THE STOMACH CONTENTS OF P. SEMISULCATUS

Palk Bay
1968

| No.of prawns | Apr. 34 | May 32 | Jun. 34 | Jul. 30 | Aug. 26 | Sep. 30 | Oct. 32 | Nov. 17 |
|---|---|---|---|---|---|---|---|---|
| Diatoms | 1.28 | 1.17 | 1.27 | 1.32 | 1.36 | 2.38 | 0.61 | --- |
| Radiolaria | 2.59 | 2.78 | 1.93 | 0.42 | --- | --- | --- | --- |
| Foraminifera | 0.34 | 0.89 | 0.45 | 0.11 | 0.14 | 0.08 | --- | --- |
| Polychaetes | 21.21 | 11.94 | 9.66 | 1.84 | 5.68 | 2.00 | 2.39 | 0.50 |
| Molluscs | 28.48 | 22.78 | 24.34 | 20.16 | 15.56 | 17.29 | 16.94 | 6.00 |
| Crustacea | 25.00 | 15.55 | 11.14 | 5.53 | 7.86 | 6.46 | 8.89 | 9.50 |
| Pisces | --- | 11.67 | 7.83 | 6.52 | 0.68 | --- | 9.72 | --- |
| Detritus | 16.03 | 26.00 | 30.45 | 54.21 | 57.77 | 60.96 | 52.00 | 64.50 |
| Sand and mud | 5.04 | 7.22 | 12.93 | 9.89 | 10.95 | 10.85 | 9.45 | 19.50 |

Crustaceans continued to remain in important food item of this species from the Gulf of Mannar.

The quantity of fish material was much less than that from Palk Bay, being totally absent in December 1968, January and March 1969.

Detritus was less abundant as in the previous year in the stomach of this species from Gulf of Mannar, occupying only fourth and fifth ranks.

The presentage of mud and sand occurring in the food of prawns from the Gulf of Mannar was less.

Variation in the food.

A comparative study of the food of P. semisulcatus during the years 1967-68 has shown that although the dietary components were essentially the same during the two years, there was variation in the importance of the individual items in the different months.

Diatoms were present throughout the first year, though in smaller quantities. But in the second year this was still less important in the diet of the species, being absent in November in Palk Bay. This item was not at all represented in the food of these prawns from the Gulf of Mannar during 1968-69 in spite of their occurrence in diet during the previous year.

Similarly, radiolarians were also less important as a food item during the year 1968-69. This item was not present in three months during the first year of observation Table XV while in the next year this was absent in four months Table XXX.

Although foraminifera were very little in the stomach contents they were absent in three months during the first year whereas only during two months in the next year this item did not occur at all.

There was definite variation in the quantity of molluscan material in the stomachs of P. semimulcatus between the first and second years. The quantity of this item was more in the stomachs during the year 1968-69 from Palk Bay as well as Gulf of Mannar.

The amount of fish item was a little more during the second year than the first although in both the years this item was absent during three months.

The bulk of the stomach contents of the species was formed by detritus in both the years in more or less equal quantities during the various months, in specimens collected from the Palk Bay. But the quantity of this item was considerably less in the stomachs of prawns from the Gul of Mannar, during both the years.

The same difference was noticed in the case of mud and sand between the samples during the two years of study from the Palk Bay and Gulf of Mannar.

From the above it would appear that there is no significant difference in the major items of the food of P. semimulcatus between the two years although the relative importance of particular items were a little different between the two years. The general pattern remained the same.

Variation between places.

Since the mechanised boats operating from Mandapam, Pamban and Rameswaram in the Palk Bay fished from the same ground there was no differe

between the food items from these major fishing centres. In the Gulf of Mannar also the areas of operation of the units are the same for Mandapam and Pamban.

But when the stomachs of samples collected from the catches from 'Thoondikadal' off Mandapam in the Gulf of Mannar, far beyond the usual inshore fishing areas the composition and abundance of the various items have been found to be quite different. It was observed that the condition of feed in these prawns was much better, actively feeding prawns being about 96.5% of the total number examined.

The items of food were the same as in the case of nearshore catches, but the percentages of each item was slightly different. Thus polychaetes formed the most important food component, molluscans and crustaceans coming second and third in importance. Foraminiferan shells were much more abundant from this area than the usual fishing ground near the shore. Detritus formed less important item in the stomach contents, (Table XXXI).

Analysis of the food of the species from the shore seines which are rarely operated during night in the Gulf of Mannar, have shown the same general composition of the dietary components as in the trawl catches. This is because of the proximity of the two fishing grounds and the consequent similarity in the bottom fauna.

The molluscan material formed most important food item while crustaceans were also abundant. There was considerable amount of detritus in the stomachs of these specimens from shore seine catches. Foraminifera were totally absent whereas radiolarians and vegetable matter formed very small portion of the food of these prawns. Mud and sand were invariably present in the stomachs analysed (Table XXXII-XXXIII).

TABLE XXXI

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF

*P. HEMISÆDULCATUS*

March 1969

Locality: Gulf of Mannar* (Trawl net) No.of prawns:54

| Stomach contents | Percentage volume (V) | Percentage occurrence (O) | V O | $\frac{VO}{Sum.VO} \times 100$ |
|---|---|---|---|---|
| Diatoms | 0.03 | 1.02 | 0.03 | 0.01 |
| Radiolaria | 4.83 | 14.21 | 68.63 | 4.83 |
| Foraminifera | 8.07 | 14.72 | 118.79 | 8.37 |
| Polychaetes | 33.00 | 14.21 | 468.93 | 33.04 |
| Molluscs | 28.28 | 14.72 | 416.28 | 29.33 |
| Crustacea | 14.17 | 14.72 | 208.58 | 14.69 |
| Pisces | 0.45 | 3.05 | 1.37 | 0.09 |
| Detritus | 4.07 | 9.64 | 39.23 | 2.76 |
| Sand and mud | 7.10 | 13.71 | 97.34 | 6.85 |
| Total | 100.00 | 100.00 | 1419.18 | 100.00 |

* THOONDIKADAL, off Mandapam.

TABLE XXXII

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF

P. SEMISULCATUS

February 1967

Locality: Gulf of Mannar (Shore seine) No.of prawns:36

| Stomach contents | Percentage volume (V) | Percentage occurrence (O) | V O | $\frac{VO}{Sum.VO} \times 100$ |
|---|---|---|---|---|
| Diatoms | 1.29 | 1.91 | 2.46 | 0.13 |
| Radiolaria | 0.58 | 1.91 | 1.11 | 0.06 |
| Foraminifera | --- | --- | --- | --- |
| Polychaetes | 6.10 | 14.01 | 85.46 | 4.66 |
| Molluscs | 31.68 | 19.75 | 625.68 | 34.11 |
| Crustacea | 35.35 | 19.75 | 698.16 | 38.06 |
| Pisces | 3.16 | 7.64 | 24.14 | 1.32 |
| Detritus | 15.32 | 19.11 | 296-59 | 16.17 |
| Sand and mud | 6.32 | 15.92 | 100.61 | 5.49 |
| Total | 100.00 | 100.00 | 1834.21 | 100.00 |

TABLE XXXIII

RELATIVE IMPORTANCE OF FOOD ITEMS IN THE STOMACH CONTENTS OF

P. SEMISULCATUS

January 1968

...lity: Gulf of Mannar (Shore seine) — No.of prawns: 33

| ...ach ...nts | Percentage volume (V) | Percentage occurrence (O) | V O | $\frac{VO}{Sum.VO} \times 100$ |
|---|---|---|---|---|
| ...ons | 0.07 | 0.76 | 0.05 | 0.003 |
| ...laria | 0.07 | 0.76 | 0.05 | 0.003 |
| ...niformis | 0.17 | 0.76 | 0.13 | 0.006 |
| ...chaetes | 13.93 | 19.85 | 276.51 | 13.903 |
| ...ceae | 28.61 | 20.62 | 589.94 | 29.662 |
| ...ceae | 37.93 | 21.37 | 810.56 | 40.766 |
| ...ae | 1.07 | 1.53 | 1.64 | 0.082 |
| ...tae | 11.36 | 16.79 | 190.73 | 9.592 |
| ...l and mud | 6.79 | 17.56 | 119.23 | 5.995 |
| ...l | 100.00 | 100.00 | 1988.84 | 100.000 |

It is seen that the general composition of the food items of prawns from shore seine catches also was similar to that of the trawl catches from the Gulf of Mannar.

## Food habits in relation to size of prawns.

Percentage occurrence of food items of P. semisulcatus in various size groups during April 1967 - March 1968 and April 1968 - March 1969 are given in Tables XXXIV - XXXVII.

It can be seen from these tables that foraminiferans were not encountered in prawns of carapace length 21-30 mm and 45-48 mm while fish item was not seen in the stomachs of prawns of 21-24 mm and 45-48 mm carapace length. Radiolarians did not form part of the food of prawns of 21-24 mm and 47-48 mm. Other items were present in all the sizes. Diatoms were more abundant in the smaller sizes while polychaetes, molluscs and crustaceans were more important in larger sizes of 31-48 mm carapace length.

There is no striking difference between the food of young and adult specimens of P. semisulcatus. The general composition of the diet remains the same although certain sizes did not have some food items in their 'stomach contents'. There appears to be little selection of particular food items as such and the presence of the various dietary components is dependant mainly on the availability of the organisms concerned. The increase in the quantity of these items is due to the increased in take of food as the prawn grows fast.

## Condition of feed

Prawns with stomachs 'gorged', 'full', 'three-fourth full' and 'half-full' were taken to have fed actively while those with 'quarter-full',

[redacted] IN VARIOUS SIZE GROUPS

Palk Bay

1968

| Size | No. of prawns | Diatom | Radiolaria | Foraminifera | Polychaetes | Molluscs | Crustacea | Pisces | Detritus | Sand and mud |
|---|---|---|---|---|---|---|---|---|---|---|
| 21-22 | 1 | 100.00 | --- | --- | 100.00 | --- | 100.00 | --- | 100.00 | 100.00 |
| 23-24 | 5 | 60.00 | --- | --- | 40.00 | --- | --- | --- | 60.00 | 20.00 |
| 25-26 | 13 | 30.77 | 7.69 | --- | 15.38 | 15.38 | 23.08 | 15.38 | 46.15 | 46.15 |
| 27-28 | 21 | 33.33 | 4.76 | --- | 28.57 | 19.05 | 23.81 | 9.58 | 55.38 | 33.33 |
| 29-30 | 23 | 56.52 | --- | --- | 34.78 | 26.09 | 26.09 | 17.39 | 65.22 | 60.87 |
| 31-32 | 19 | 68.42 | 10.53 | 5.26 | 52.63 | 42.10 | 42.10 | 5.26 | 73.68 | 52.62 |
| 33-34 | 20 | 55.00 | 15.00 | --- | 55.00 | 35.00 | 50.00 | 5.00 | 75.00 | 50.00 |
| 35-36 | 23 | 52.17 | 21.75 | --- | 56.52 | 43.48 | 65.22 | 13.04 | 93.91 | 82.61 |
| 37-38 | 22 | 68.18 | 18.18 | 4.55 | 86.36 | 45.45 | 59.09 | --- | 90.91 | 59.09 |
| 39-40 | 20 | 55.00 | 20.00 | 10.00 | 75.00 | 55.00 | 65.00 | 5.00 | 75.00 | 55.00 |
| 41-42 | 27 | 48.15 | 7.41 | 7.41 | 62.96 | 40.74 | 66.67 | 18.51 | 85.19 | 62.95 |
| 43-44 | 13 | 30.77 | 15.38 | --- | 76.92 | 53.85 | 63.85 | 23.08 | 92.31 | 53.85 |
| 45-46 | 5 | 20.00 | 20.00 | --- | 80.00 | 80.00 | 80.00 | --- | 60.00 | 40.00 |
| 47-48 | 1 | --- | --- | --- | 100.00 | 100.00 | 100.00 | --- | 100.00 | 100.00 |

[redacted] at various size groups

Palk Bay

1968

| Size | No. of prawns | Diatom | Radiolaria | Foraminifera | Polychaetes | Molluscs | Crustaceans | Pisces | Detritus | Sand and mud |
|---|---|---|---|---|---|---|---|---|---|---|
| 19-20 | 1 | 100.00 | 100.00 | — | 100.00 | 100.00 | 100.00 | — | 100.00 | 100.00 |
| 21-22 | 3 | — | — | — | — | 66.67 | 33.33 | — | 33.33 | 66.67 |
| 23-24 | 6 | 16.67 | — | — | 33.33 | 16.67 | 33.33 | — | 33.33 | 33.33 |
| 25-26 | 21 | 19.05 | 9.52 | — | 28.57 | 42.86 | 42.86 | 4.76 | 61.90 | 42.86 |
| 27-28 | 28 | 39.39 | 10.71 | 3.57 | 32.14 | 39.29 | 35.74 | 25.00 | 67.85 | 50.00 |
| 29-30 | 22 | 45.45 | — | 4.55 | 13.64 | 31.82 | 22.72 | 18.18 | 68.18 | 68.18 |
| 31-32 | 20 | 35.00 | 20.00 | 20.00 | 40.00 | 50.00 | 40.00 | 50.00 | 60.00 | 65.00 |
| 33-34 | 28 | 28.57 | 14.29 | 7.14 | 32.14 | 46.43 | 32.14 | 3.57 | 50.00 | 46.43 |
| 35-36 | 30 | 33.33 | 20.00 | 10.00 | 56.67 | 50.00 | 60.00 | 23.33 | 80.00 | 76.67 |
| 37-38 | 20 | 45.00 | 15.00 | — | 25.00 | 40.00 | 40.00 | 20.00 | 75.00 | 60.00 |
| 39-40 | 23 | 47.83 | 17.39 | 4.35 | 47.83 | 52.17 | 39.13 | 17.39 | 86.96 | 73.91 |
| 41-42 | 13 | 36.15 | 7.69 | — | 23.08 | 38.46 | 38.46 | 7.69 | 84.62 | 84.62 |
| 43-44 | 7 | 42.86 | — | 14.29 | 42.86 | 57.14 | 14.29 | 14.29 | 85.71 | 85.71 |
| 45-46 | 11 | 27.27 | — | — | 54.55 | 54.55 | 36.36 | 9.09 | 72.73 | 63.64 |
| 47-48 | 2 | 50.00 | — | — | 50.00 | 50.00 | 50.00 | — | 50.00 | 50.00 |

PERCENTAGE OCCURRENCE OF FOOD ITEMS PRESENT IN THE STOMACH CONTENTS OF *P. SEMISULCATUS* IN VARIOUS SIZE GROUPS

Gulf of Mannar

1967 - 1968

| Size | No. of prawns | Diatom | Radiolaria | Foraminifera | Polychaetes | Molluscs | Crustacea | Pisces | Detritus | Sand and mud |
|---|---|---|---|---|---|---|---|---|---|---|
| 21-22 | 8 | 62.50 | 87.50 | 37.50 | 87.50 | 87.50 | 75.00 | — | 87.50 | 37.50 |
| 23-24 | 2 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | — | 100.00 | — |
| 25-26 | 14 | 50.00 | 42.86 | — | 78.57 | 71.43 | 71.43 | 7.14 | 85.71 | 42.86 |
| 27-28 | 10 | 50.00 | 20.00 | 10.00 | 70.00 | 100.00 | 80.00 | — | 80.00 | 60.00 |
| 29-30 | 7 | 71.43 | 42.83 | — | 57.14 | 85.71 | 85.71 | 14.29 | 85.71 | 28.57 |
| 31-32 | 17 | 29.41 | 17.65 | 11.76 | 70.59 | 82.35 | 82.35 | — | 88.23 | 64.71 |
| 33-34 | 11 | 36.36 | 45.45 | 27.27 | 72.73 | 100.00 | 100.00 | — | 100.00 | 54.55 |
| 35-36 | 14 | 28.57 | 28.57 | 7.14 | 92.86 | 92.86 | 85.71 | 7.14 | 100.00 | 64.29 |
| 37-38 | 6 | — | 33.33 | 16.67 | 66.67 | 100.00 | 83.33 | — | 83.33 | 100.00 |
| 39-40 | 4 | 50.00 | — | 25.00 | 75.00 | 75.00 | 50.00 | — | 50.00 | — |
| 41-42 | 5 | 20.00 | 40.00 | 20.00 | 60.00 | 60.00 | 60.00 | — | 60.00 | 40.00 |
| 43-44 | 5 | 40.00 | 20.00 | — | 40.00 | 40.00 | 40.00 | — | 80.00 | 60.00 |
| 45-46 | 1 | — | 100.00 | — | 100.00 | 100.00 | 100.00 | — | — | 100.00 |
| 47-48 | 2 | — | — | — | 100.00 | 50.00 | 100.00 | — | 100.00 | — |
| 49-50 | 2 | 50.00 | — | — | 100.00 | 50.00 | 50.00 | — | 100.00 | 50.00 |

## CONTENTS OF *P. SEMIRELIGATUS* IN VARIOUS SIZE GROUPS

Gulf of Mannar

1968 - 1969

| Size | No. of prawns | Diatom | Radiolaria | Foraminifera | Polychaetes | Molluscs | Crustacea | Pisces | Detritus | Sand and mud |
|---|---|---|---|---|---|---|---|---|---|---|
| 17-18 | 3 | — | — | — | — | 66.67 | 66.67 | — | 66.67 | 66.67 |
| 19-20 | 1 | — | — | — | 100.00 | 100.00 | 100.00 | — | 100.00 | 100.00 |
| 21-22 | 6 | — | 66.67 | — | 83.33 | 100.00 | 100.00 | — | 100.00 | 100.00 |
| 23-24 | 7 | — | 14.29 | — | 57.14 | 71.43 | 57.14 | — | 57.14 | 71.43 |
| 25-26 | 12 | — | 66.67 | — | 91.67 | 100.00 | 100.00 | — | 100.00 | 91.67 |
| 27-28 | 11 | — | 27.27 | — | 72.73 | 81.82 | 81.82 | — | 8182 | 63.64 |
| 29-30 | 13 | — | 30.77 | 7.69 | 84.62 | 84.62 | 84.62 | — | 84.62 | 69.23 |
| 31-32 | 7 | — | 27.27 | — | 100.00 | 100.00 | 100.00 | — | 22.73 | 100.00 |
| 33-34 | 14 | — | 42.86 | — | 71.43 | 78.57 | 78.57 | — | 71.43 | 78.57 |
| 35-36 | 17 | — | 64.71 | — | 94.12 | 94.12 | 94.12 | 5.88 | 82.35 | 94.12 |
| 37-38 | 18 | — | 55.56 | 11.11 | 94.44 | 24.44 | 94.44 | 11.11 | 88.89 | 94.44 |
| 39-40 | 12 | — | 75.00 | — | 91.67 | 91.67 | 91.67 | — | 91.67 | 83.33 |
| 41-42 | 2 | — | — | — | 100.00 | 100.00 | 100.00 | — | 100.00 | 100.00 |
| 43-44 | 3 | — | 33.33 | — | 100.00 | 100.00 | 100.00 | — | 100.00 | 100.00 |
| 45-46 | 2 | — | 100.00 | — | 100.00 | 100.00 | 100.00 | — | 100.00 | 100.00 |

'trace' and 'empty' stomachs were considered as poorly fed. The percentages of volume of actively feeding prawns are shown in Table XXXVIII-XXXIX.

The prawns from Palk Bay were mostly poorly fed ones. The percentages of actively fed ones ranged from 5.88 to 61.76. During the months of May, June and September this was less than 20% in the first year while this condition was observed during July, September and November in the second year of observation. In the year 1967-68 the actively feeding prawns in the samples analysed formed about 30% during the months of July, August and October while it was 55.88% to in March. The year 1968-69 registered better percentages of the actively fed prawns. In July and November only the percentage of actively feeding prawns were less than 10% while in August it was 26%. Higher percentages were recorded from 34 in May to about 50 in June and 60 in April (Table XL-XLII).

The condition of feed of the prawns collected from the Gulf of Mannar was better during both the years. The percentages of actively feeding prawns in the samples examined during November 1967 to February 1968 had arrange of 42 to 85, (the peak period being January in the first year) and 57.6 to 78.8 during December 1968 to March 1969.

The comparision of the condition of feed of prawns of different sizes revealed that no difference in the intensity of feeding has been exhibited between the smaller and larger sizes. There was no variation, in this respect, between the months. Thus from the Palk Bay samples a few specimens were obtained in actively fed condition, both in the mxm smaller size range (25-28 mm) and larger size range (37-40 mm) during May and September 1967. At the same time in the months of July and October of the same year prawns of the sizes 33-42 mm and 25-38 mm, were found with stomachs in the various degrees of fullness, from 'gorged' to 'half-full', while

TABLE XXXVIII

PERCENTAGE OCCURRENCE OF ACTIVELY FEEDING *P. SEMISULCATUS* IN EACH MONTH

Palk Bay

1967 - 1968

| | Apr. 1967 | May 1967 | Jun. 1967 | Jul. 1967 | Aug. 1967 | Sep. 1967 | Oct. 1967 | Nov. 1968 |
|---|---|---|---|---|---|---|---|---|
| No. of prawns | 17 | 26 | 21 | 29 | 28 | 34 | 27 | 34 |
| Percentage | --- | 11.54 | --- | 27.58 | 25.00 | 14.70 | 29.63 | 55.88 |

1968

| | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. |
|---|---|---|---|---|---|---|---|---|
| No. of prawns | 34 | 32 | 34 | 30 | 26 | 30 | 32 | 17 |
| Percentage | 61.76 | 34.38 | 49.99 | 6.66 | 26.92 | 13.33 | 18.76 | 5.88 |

TABLE XXXIX

Gulf of Mannar

1967 - 1969

| | Nov 1967 | Dec. 1967 | Jan. 1968 | Feb. 1968 | Dec. 1968 | Jan. 1969 | Feb. 1969 | Mar. 1969 |
|---|---|---|---|---|---|---|---|---|
| No. of prawns | 30 | 31 | 20 | 25 | 33 | 33 | 33 | 33 |
| Percentage | 70.00 | 58.06 | 85.00 | 42.00 | 78.78 | 72.72 | 57.57 | 78.78 |

**TABLE XI**

PERCENTAGE OCCURRENCE OF STOMACHS OF *P. SEMISULCATUS* IN VARIOUS DEGREES OF FULLNESS

Palk Bay

1967 - 1968

| | Apr. 1967 | May 1967 | Jun. 1967 | Jul. 1967 | Aug. 1967 | Sep. 1967 | Oct. 1967 | Mar. 1968 |
|---|---|---|---|---|---|---|---|---|
| No. of prawns | 17 | 26 | 21 | 29 | 28 | 34 | 27 | 34 |
| **Condition of feed** | | | | | | | | |
| Gorged | --- | --- | --- | --- | --- | --- | --- | 2.94 |
| Full | --- | 3.85 | --- | --- | --- | --- | 3.70 | 8.82 |
| ¾ Full | --- | --- | --- | 17.24 | 3.57 | 5.88 | 18.51 | 23.53 |
| ½ Full | --- | 7.69 | 4.76 | 10.34 | 14.29 | 8.82 | 7.41 | 20.59 |
| ¼ Full | 41.18 | 19.23 | 23.81 | 20.69 | 35.71 | 11.76 | 14.81 | 29.41 |
| Trace | 29.41 | 50.00 | 33.33 | 20.69 | 35.71 | 41.18 | 18.51 | 5.88 |
| Empty | 29.41 | 19.23 | 38.10 | 31.03 | 3.57 | 32.35 | 37.04 | 8.82 |

TABLE XLI

PERCENTAGE OCCURRENCE OF STOMACHS OF *P. SEMISULCATUS* IN VARIOUS DEGREES OF FULLNESS

Palk Bay
1968

| | Apr. | May | Jun. | Jul | Aug. | Sep. | Oct. | Nov. |
|---|---|---|---|---|---|---|---|---|
| No. of prawns | 34 | 32 | 34 | 30 | 26 | 30 | 32 | 17 |
| **Condition of feed** | | | | | | | | |
| Gorged | --- | --- | --- | --- | --- | --- | --- | --- |
| Full | 8.82 | 6.25 | 8.82 | --- | 15.38 | --- | 3.13 | --- |
| ¾ Full | 35.29 | 18.75 | 29.41 | 3.33 | 3.85 | 3.33 | 6.25 | --- |
| ½ Full | 17.65 | 9.38 | 11.76 | 3.33 | 7.69 | 10.00 | 9.38 | 5.88 |
| ¼ Full | 17.65 | 12.50 | 11.76 | 33.33 | 30.77 | 33.33 | 9.38 | 17.65 |
| Trace | 5.88 | 9.38 | 23.53 | 23.33 | 26.92 | 33.33 | 28.13 | 35.29 |
| Empty | 14.71 | 43.75 | 14.71 | 36.67 | 15.38 | 20.00 | 43.75 | 41.18 |

TABLE XLII

PERCENTAGE OCCURRENCE OF STOMACHS OF P. SEMISULCATUS IN VARIOUS DEGREES OF FULLNESS

Gulf of Mannar

1967 - 1969

| | Nov. 1967 | Dec. 1967 | Jan. 1968 | Feb. 1968 | Dec. 1968 | Jan. 1969 | Feb. 1969 | Mar. 1969 |
|---|---|---|---|---|---|---|---|---|
| No. of prawns | 30 | 313 | 20 | 25 | 33 | 33 | 33 | 33 |
| **Condition of feed** | | | | | | | | |
| Gorged | — | — | 10.00 | — | — | 3.03 | — | — |
| Full | 6.67 | — | 10.00 | 4.00 | 12.12 | 15.15 | 9.90 | 12.12 |
| ¾ Full | 20.00 | 19.35 | 25.00 | 12.00 | 33.33 | 30.30 | 21.21 | 30.30 |
| ½ Full | 43.33 | 38.71 | 40.00 | 24.00 | 33.33 | 24.24 | 27.27 | 36.36 |
| ¼ Full | 16.67 | 16.13 | 15.00 | 48.00 | 15.15 | 24.24 | 12.12 | 15.15 |
| Trace | 6.67 | 22.58 | — | — | — | — | 9.09 | 3.03 |
| Empty | 6.67 | 3.23 | — | 12.00 | 6.06 | 3.03 | 21.21 | 3.03 |

actively feeding individuals were encountered in August only within the size range of 41-48 mm. More than half the number of prawns examined during March 1968 were actively fed ranging in length from 31-46 mm. Tables XLIII-XLV.

During the second year of the present study P. semisulcatus exhibited better condition of feed in smaller specimens in April, May and October while larger prawns were actively fed in the months of August and September. In June the actively feeding individuals were from the size range of 27-46 mm.

In the Gulf of Mannar, actively feeding prawns ranged in size from 21-34 mm in November and 25-38 mm in December 1967 whereas this range was from 21-46 mm in January and from 25-50 mm in February 1968. In all the four months during the second year, prawns of size 19-20 mm to 39-40 mm were found to be actively feeding. There was no marked difference in the condition of feed of P. semisulcatus of the various size groups.

## Selectivity of feeding

Analysis of the stomach contents of P. semisulcatus has shown that they do not exhibit preference to any particular type of food items, although in certain months some of the items were predominent in the stomachs. Thus molluscan materials formed the bulk of the stomach contents during the months of August, September, November, December 1967 and January and March 1968. The food consisted largely of detritus in all the months from April to December 1967 and in February 1968. This may be due to the fact that during these months the particular items might have been abundant in the bottom fauna rather than due to selective feeding by the individual prawns.

TABLE XLIII

PERCENTAGE OCCURRENCE OF ACTIVELY FEEDING P. SEMISULCATUS

IN VARIOUS SIZE GROUPS

Palk Bay

1967 - 1968

| Months / Size groups | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Mar. |
|---|---|---|---|---|---|---|---|---|
| 21-22 | -- | -- | -- | -- | -- | -- | Nil | -- |
| 23-24 | -- | Nil | -- | -- | -- | Nil | Nil | -- |
| 25-26 | Nil | 50 | -- | -- | -- | Nil | 26 | -- |
| 27-28 | Nil | Nil | Nil | -- | Nil | 20 | 25 | Nil |
| 29-30 | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil |
| 31-32 | Nil | Nil | 33 | Nil | Nil | Nil | 33 | 60 |
| 33-34 | Nil | Nil | Nil | 25 | Nil | Nil | 66 | 60 |
| 35-36 | Nil | Nil | Nil | 40 | Nil | Nil | 100 | 33 |
| 37-38 | Nil | Nil | Nil | 40 | Nil | 25 | 100 | 66 |
| 39-40 | Nil | 33 | Nil | 33 | Nil | Nil | Nil | 60 |
| 41-42 | Nil | Nil | Nil | 40 | 43 | Nil | Nil | 100 |
| 43-44 | -- | Nil | Nil | Nil | 50 | 100 | -- | 50 |
| 45-46 | -- | Nil | -- | Nil | 100 | 100 | -- | 100 |
| 47-48 | -- | -- | -- | -- | 100 | -- | -- | -- |

TABLE XLIV

PERCENTAGE OCCURRENCE OF ACTIVELY FEEDING P. SEMISULCATUS

IN VARIOUS SIZE GROUPS

Palk Bay

1968

| Months / Size groups | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. |
|---|---|---|---|---|---|---|---|---|
| 19-20 | 100 | -- | -- | -- | -- | -- | -- | -- |
| 21-22 | Nil | -- | -- | -- | -- | -- | 50 | -- |
| 23-24 | 50 | Nil | -- | -- | -- | -- | Nil | -- |
| 25-26 | 80 | 40 | Nil | Nil | Nil | Nil | 60 | Nil |
| 27-28 | 80 | 20 | 33 | Nil | Nil | Nil | 33 | Nil |
| 29-30 | 100 | Nil | 100 | Nil | Nil | Nil | Nil | Nil |
| 31-32 | 50 | 50 | 43 | Nil | Nil | Nil | Nil | Nil |
| 33-34 | 25 | 43 | 25 | Nil | 17 | Nil | Nil | Nil |
| 35-36 | 75 | 25 | 67 | Nil | 50 | Nil | 25 | 100 |
| 37-38 | Nil | 100 | Nil | 33 | Nil | Nil | Nil | -- |
| 39-40 | 100 | 100 | 40 | Nil | 33 | Nil | Nil | Nil |
| 41-42 | 100 | -- | -- | Nil | 50 | 25 | 50 | Nil |
| 43-44 | -- | -- | 100 | Nil | 100 | 50 | -- | Nil |
| 45-46 | Nil | -- | 100 | Nil | 50 | 100 | Nil | Nil |
| 47-48 | Nil | -- | -- | -- | -- | -- | -- | -- |

TABLE XLV

PERCENTAGE OCCURRENCE OF ACTIVELY FEEDING P.SEMISULCATUS

IN VARIOUS SIZE GROUPS

Gulf of Mannar

| Months | 1967-1968 | | | | 1968-1969 | | | |
|---|---|---|---|---|---|---|---|---|
| Size groups | Nov. | Dec. | Jan. | Feb. | Dec. | Jan. | Feb. | Mar. |
| 19-20 | -- | -- | -- | -- | -- | -- | 100 | -- |
| 21-22 | 100 | -- | 100 | -- | -- | 50 | 100 | 100 |
| 23-24 | 100 | -- | Nil | -- | -- | 100 | 50 | 75 |
| 25-26 | 100 | 33 | 50 | 25 | 50 | 100 | 66 | 100 |
| 27-28 | 50 | 60 | 100 | -- | 75 | 66 | 33 | 100 |
| 29-30 | 50 | 100 | 100 | -- | 60 | 33 | 33 | 50 |
| 31-32 | 75 | 60 | 66 | 40 | 100 | 100 | 100 | 50 |
| 33-34 | 33 | 57 | 100 | -- | 100 | 25 | 50 | 100 |
| 35-36 | 100 | 60 | 100 | 25 | 60 | 100 | 100 | 75 |
| 37-38 | -- | 50 | 100 | -- | 100 | 86 | 100 | 100 |
| 39-40 | -- | -- | -- | 75 | 80 | 66 | Nil | 100 |
| 41-42 | -- | -- | 50 | 100 | -- | -- | -- | 100 |
| 43-44 | -- | -- | 100 | Nil | -- | -- | -- | 33 |
| 45-46 | -- | -- | 100 | -- | -- | 100 | -- | 100 |
| 47-48 | -- | -- | -- | 50 | -- | -- | -- | -- |
| 49-50 | -- | -- | -- | 50 | -- | -- | -- | -- |

In the laboratory these prawns promptly accepted most of the types of animal food such as clams and pieces of fish and even fresh prawns used as food of other aquarium animals. They thrived well on dried food prepared by mixing 2 parts rice flour, 2 parts wheat flour and 1 part dried whole prawn powder.

Although the specific identity of crustaceans forming the food could not be ascertained it is quite probable that any of the smaller crustaceans occurring along with this species in the nets (Table XLIV) might form major portion of this item.

## Feeding habits.

There is no doubt about the bottom feeding habit of P.semisulcatus. The food consists of bottom living animals like lamellibranch and gastropod molluscs, polychaetes, crustaceans, foraminiferans and radiolarians. The monthly precentage of occurrence of the various items present in the stomachs are given in Table XLVI-XLVIII.

During certain months the stomachs were almost full of Polychaete tissue whereas in other months the lamellibranchs were the exclusive food item of this species. Majority of the stomachs contained more than one food item in varying degrees of abundance indicating that there is no preference exhibited for any food item in particular.

Consequent on the increased activity of these prawns by night the intensity of feeding also is more during the dark hours of the day. This habit showed in the season for the occurrence of more better condition of feed specimens in the Gulf of Mannar where fishing was mostly done during

OF *P. SEMISULCATUS*

Palk Bay

1967 - 1968

| | Apr. 1967 | May 1967 | Jun. 1967 | Jul. 1967 | Aug. 1967 | Sep. 1967 | Oct. 1967 | Mar. 1968 |
|---|---|---|---|---|---|---|---|---|
| No. of prawns | 17 | 26 | 21 | 29 | 28 | 34 | 27 | 34 |
| Diatoms | 58.82 | 61.54 | 61.09 | 58.62 | 42.86 | 61.76 | 22.22 | 41.18 |
| Radiolaria | --- | --- | --- | 17.24 | 3.57 | --- | 37.04 | 35.29 |
| Foraminifera | 5.88 | 3.85 | --- | 3.45 | --- | --- | 3.70 | 5.56 |
| Polychaetes | 47.06 | 46.15 | 57.14 | 55.17 | 67.86 | 41.18 | 48.15 | 88.24 |
| Molluscs | 17.65 | 11.54 | 4.76 | 17.24 | 60.71 | 32.35 | 29.63 | 79.41 |
| Crustaceans | 5.88 | 34.62 | 19.05 | 37.93 | 71.43 | 38.24 | 48.15 | 82.35 |
| Pisces | --- | 11.54 | --- | 17.24 | 35.71 | 14.71 | 11.11 | --- |
| Detritus | 70.59 | 76.92 | 61.90 | 65.52 | 96.43 | 67.65 | 59.26 | 79.41 |
| Sand and mud | 41.18 | 69.23 | 61.90 | 62.07 | 75.00 | 55.88 | 62.96 | 20.59 |

P. SEMISULCATUS

Palk Bay

1968

| | Apr. 1968 | May 1968 | Jun. 1968 | Jul. 1968 | Aug. 1968 | Sep. 1968 | Oct. 1968 | Nov. 1968 |
|---|---|---|---|---|---|---|---|---|
| No. of prawns | 34 | 32 | 34 | 30 | 26 | 30 | 32 | 17 |
| Diatoms | 38.24 | 18.75 | 50.00 | 36.67 | 53.67 | 73.33 | 15.63 | — |
| Radiolaria | 29.41 | 28.13 | 22.24 | 3.33 | — | — | — | — |
| Foraminifera | 5.56 | 15.63 | 14.71 | 3.33 | 3.85 | 3.34 | — | — |
| Polychaetes | 73.53 | 50.00 | 73.53 | 13.33 | 34.62 | 13.33 | 9.38 | 5.88 |
| Molluscs | 76.47 | 43.75 | 64.70 | 40.00 | 38.45 | 36.67 | 21.88 | 17.64 |
| Crustacea | 79.41 | 50.00 | 61.77 | 30.00 | 23.08 | 16.67 | 18.76 | 23.52 |
| Pisces | — | 9.38 | 50.00 | 33.33 | 7.69 | — | 15.63 | — |
| Detritus | 76.47 | 53.13 | 85.29 | 63.34 | 84.59 | 80.00 | 53.13 | 58.82 |
| Sand and mud | 52.94 | 37.50 | 85.29 | 60.00 | 80.78 | 80.00 | 53.13 | 58.82 |

PERCENTAGE OCCURRENCE OF FOOD ITEMS PRESENT IN THE STOMACH CONTENTS

OF *P. SEMISULCATUS*

Gulf of Mannar

1967 - 1968

| | Nov. 1967 | Dec. 1967 | Jan. 1968 | Feb. 1968 | Dec. 1968 | Jan. 1969 | Feb. 1969 | Mar. 1969 |
|---|---|---|---|---|---|---|---|---|
| No. of prawns | 30 | 31 | 20 | 25 | 33 | 33 | 33 | 33 |
| Diatoms | 93.33 | 9.68 | — | 44.00 | — | — | — | — |
| Radiolaria | 63.34 | 35.48 | 45.00 | — | 63.64 | 62.52 | 24.24 | 42.42 |
| Foraminifera | 26.67 | 9.68 | 15.00 | 12.00 | 6.06 | 3.13 | — | — |
| Polychaetes | 80.00 | 58.06 | 95.00 | 80.00 | 93.94 | 100.00 | 69.70 | 84.85 |
| Molluscs | 90.00 | 96.77 | 100.00 | 52.00 | 93.94 | 100.00 | 78.79 | 96.97 |
| Crustacea | 76.67 | 93.55 | 90.00 | 60.00 | 93.94 | 100.00 | 78.79 | 90.91 |
| Pisces | — | — | 5.00 | 12.00 | — | — | 12.12 | — |
| Detritus | 93.33 | 90.32 | 75.00 | 84.00 | 90.91 | 93.78 | 72.73 | 90.91 |
| Sand and mud | 3.33 | 87.10 | 85.00 | 52.00 | 90.91 | 100.00 | 72.73 | 87.88 |

night. P. semisulcatus kept in aquaria have been observed to be more active during night. During day time they keep themselves buried in the bottom sand, coming out only at the time of feeding.

Since full or part of P. semisulcatus was not found in stomachs examined it is presumed that this species does not exhibit cannibalistic habit. None of the specimens kept in the aquaria did show any tendency towards cannibalism.

Discussion: Several workers have reported that the main items of food of prawns consisted of detritus, bottom living animals like foraminifera, polychaetes and small crustaceans in addition to diatoms and algal filaments. Gopalakrishnan (1952) observed that crustaceans and vegetable matter formed bulk of the gut contents of Penaeus indicus while Metapenaeus dobsoni is reported (Menon, 1951) to feed on small animals and diatoms along with mud and sand. The food of Parapenaeopsis stylifera consisted of detritus and small animals (Menon, 1953). Panikkar and Menon (1956) also found that P. indicus, M. dobsoni and P. stylifera were detritus feeders although small amounts of animal remains, sand and mud were also encountered in their gut contents. Subrahmanyam (1967) concluded that M. affinis was carnivorous in habit. This view is supported by Thomas (MS) in the case if Penaeus monodon from Korapuzha Estuary. Kishinouye (1900), Hiratsu (1955), Kubo (1956) and Yasuda (1956) also reported the carnivorous food habits of the various penaeid prawns they studied. Hall (1962) while studying the food of penaeid prawns from Singapore found that P. semisulcatus fed on polychaetes, crustaceans, pisces and vegetable matter.

The present investigation on P. semisulcatus from Palk Bay and Gulf of Mannar during the period 1967-68 has shown that the food of the species consisted of polychaetes, crustaceans, molluscs, diatoms, radiolarian, pisces and foraminiferans in the order of importance, although detritus was quite abundant. During the year 1968-69 molluscs ranked first among the constituents of food of this species while crustaceans, polychaetes pisces, radiolarians and diatoms occurred in the order of abundance. From the Gulf of Mannar, it was found that the proportions of the various items, of food differed from those from Palk Bay, although, there was no change in the items. Thus molluscs were most abundant followed by crustaceans, polychaetes, radiolarians, diatoms, pisces and formainiferans during the two years under investigation.

There was no marked difference in the food and feeding habits of P. semisulcatus of various size groups. Gopalakrishnan (op.cit.) also did not notice any such difference in the diet of small and large specimens of P. indicus from Madras. But Menon (op.cit) observed that vegetable matter was eaten less by the larger individuals of M. dobsoni.

The percentage of actively feeding prawns was found to be higher in the samples caught in the night, indicating that they were more actively feeding during the dark hours of the day. Besides, it has been observed that they do not exhibit any preferance to a particular type of food during one season or other. From the frequency and percentage volume of the individual tems in the various months it was evident that the abundance of a particular food item was dependant on the availability of that item in plenty during the season when they were dominating in the stomach contents. The presence of mud, sand and detritus with very little quantities of algal material could only be

attributed to the bottom feeding habit of the prawns. Since these items do not have much food value the prawns depend mainly on the animal matter consumed and hence they can be considered carnivorous in habit.

## AGE AND GROWTH

The studies on age and growth of a commercially important species of prawn is significant in that it leads to an understanding of the age class structure of the stock and the role played by the different year-classes in the fluctuations of the fishery. This knowledge is also essential to asses the mortality and survival rate of various year-classes and the success of the yearly brood, all of which contribute towards the rational exploitation of the stocks.

The age and growth rate of prawns can be estimated by the analysis of length frequency data using Petersen's method, or probability plot analysis in addition to marking by tags and vital stains and by determining actual growth rate by rearing in aquaria.

### Length frequency analysis

This method is relatively quick as it involves only the length measurements of prawns. It is assumed that the lengths of individuals of the same age group in a population are approximately normally distributed. The length frequency distribution generally presents a multimodal curve if there are more than one specific spawning period in an year. These modes can be separated in the earlier period although the process becomes difficult as the growth slows down with age and result in considerable overlapping of the modes. Therefore in animals with prolonged spawning period extreme care is necessary to apply this method and in such cases it will be only possible to trace a size group as far as possible after its entry into the commercial fishery and find the average monthly growth rate in different stages from which the approximate values of average size at different ages may be calculated. Since the species under investigation has a prolonged spawning period the above method was employed.

Random samples of P. semisulcatus were collected from the mechanised boat catches of Mandapam for a period from April 1967 to March 1969. In all cases the prawns were preserved in 5% formalin. After separating the sexes total length from the tip of the rostrum to tip of telson and carapace length from the postorbital margin to the posteromedian margin of carapace were taken. Care was taken to exclude specimens with broken rostrum and telson. For the purpose of length frequency analysis only carapace length which could be taken more accurately was utilised. The length measurements were grouped into 2 mm size groups. The data for each month was pooled to avoid any error due to false sampling and the progression of modes traced.

The total number of prawns in each size group are shown in Tables XLIX - LII. The length frequency curves are drawn for each month for the period April 1967 to March 1969 (Pl.XIX, 1 & 2).

The lengths at age 12 months and 24 months were computed using Bertalanffy's equation and compared with the values obtained by Peterson's method.

$$l_t = l_\infty \left[ 1 - e^{-K (t - t_o)} \right]$$

where $l_t$ = length at age t; $l_\infty$ = asymptotic length or maximum length which can be reached by the animal.

The above equation can be rewritten as follows:

$$l_t + 1 = a + b\, l_t, \text{ where } b = e^{-K} \text{ and } a = l_\infty (1 - e^{-K})$$

This is a linear equation in terms of $(l_t)$ and $(l_{t+1})$. The values of b and a are estimated by the method of least squares taking $l_t$ as x and $(l_{t+1})$ as y.

During the year 1967-68 female prawns exhibited two modes in most of the months (Table XLIX). The mode at 29 - 30 mm in April, 1967 remained same in succeeding month; but increased to 33 - 34 mm in June and 37 - 38 mm in July. This modal size was maintained during the months of August and September. In October the mode increased further to 39 - 40 mm and remained same in November. The progression of this mode could not be traced in December to January although in February the dominant size, was at 43 - 44 mm. The progression of modes in the second year also was more or less of the same pattern (Table L). Thus it is seen that the growth rate in females was more than that of males. This seems to be quite in agreement with the larger size of females.

The progression of mode were traced in females, in a sequential manner. The mean values of each month shows that the average growth from 30.0 mm in the first month to 33.5 mm in the second month is 3.5 mm. As the growth in earlier months will be faster in all animals the age at 30.0 mm carapace length cannot be more than 7 months. Therefore, at 12 months the carapace length is 38.2 mm at 19 months 41.5 mm. Applying Bertalanffy's equation,

$$b = 0.710 \text{ and } a = 11.92$$

$$K = 0.343$$

$$l = \frac{a}{1-b} = 41.13 \text{ mm}$$

The values for sum t = 115; n = 10 and

$$\frac{1}{K}\left[\log e\,(1 - l_t/l_\infty)\right] = -7.26$$

Therefore, $t_o = 11.50 - 7.26$

$= 4.24$

Therefore, $l_{12} = 41.13\left[1 - e^{-0.34\,(12 - 4.24)}\right]$

$= 30.16$ mm

TABLE XLIX

LENGTH FREQUENCY DATA OF P. SEMISULCATUS

1967 - 1968

| Size groups | No. of females taken per month in each size group | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Apr. | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. |
| 19-20 | 1 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 21-22 | 1 | 2 | 1 | -- | -- | -- | -- | -- | -- | 4 | -- | -- |
| 23-24 | 4 | 7 | 6 | -- | -- | -- | -- | 5 | 5 | 2 | 2 | 3 |
| 25-26 | 28 | 16 | 7 | 3 | 4 | -- | -- | 6 | 17 | 3 | 12 | 11 |
| 27-28 | 37 | 25 | 18 | 9 | 3 | 12 | 7 | 11 | 14 | 11 | 16 | 15 |
| 29-30 | 40 | 41 | 33 | 13 | 12 | 19 | 17 | 21 | 64 | 34 | 32 | 17 |
| 31-32 | 31 | 36 | 44 | 30 | 28 | 16 | 27 | 24 | 59 | 29 | 32 | 14 |
| 33-34 | 29 | 39 | 56 | 60 | 36 | 44 | 38 | 29 | 49 | 39 | 36 | 39 |
| 35-36 | 19 | 43 | 47 | 65 | 33 | 37 | 98 | 23 | 37 | 27 | 47 | 30 |
| 37-38 | 20 | 21 | 40 | 67 | 51 | 75 | 47 | 22 | 15 | 19 | 37 | 40 |
| 39-40 | 12 | 22 | 22 | 34 | 36 | 45 | 57 | 39 | 12 | 17 | 27 | 17 |
| 41-42 | 7 | 11 | 12 | 22 | 33 | 38 | 39 | 10 | 6 | 14 | 27 | 11 |
| 43-44 | -- | 6 | 8 | 15 | 8 | 15 | 12 | 11 | -- | 4 | 32 | 8 |
| 45-46 | 1 | 3 | 4 | 5 | 2 | 8 | 12 | 3 | -- | 2 | 10 | 3 |
| 47-48 | -- | 1 | 3 | -- | 2 | 1 | 2 | -- | -- | -- | 9 | 1 |
| 49-50 | -- | -- | -- | -- | -- | 1 | -- | -- | -- | -- | 4 | -- |

TABLE X

LENGTH FREQUENCY DATA OF P. SEMISULCATUS

1968 - 1969

| Size groups | No. of females taken per month in each size group | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Apr. | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. |
| 21-22 | 1 | 1 | — | — | — | — | 1 | 7 | 13 | 4 | 4 | 5 |
| 23-24 | 8 | 7 | 7 | 1 | 2 | 1 | 3 | 12 | 48 | 10 | 31 | 13 |
| 25-26 | 30 | 28 | 11 | 8 | 2 | 5 | 2 | 13 | 119 | 13 | 100 | 31 |
| 27-28 | 26 | 42 | 27 | 10 | 15 | 8 | 17 | 31 | 91 | 15 | 110 | 28 |
| 29-30 | 43 | 71 | 35 | 20 | 12 | 14 | 10 | 44 | 49 | 24 | 65 | 33 |
| 31-32 | 57 | 80 | 70 | 45 | 21 | 13 | 21 | 28 | 32 | 40 | 36 | 40 |
| 33-34 | 38 | 71 | 59 | 51 | 40 | 33 | 36 | 33 | 33 | 41 | 17 | 30 |
| 35-36 | 46 | 59 | 54 | 42 | 49 | 51 | 46 | 23 | 22 | 76 | 13 | 16 |
| 37-38 | 48 | 46 | 47 | 64 | 51 | 53 | 44 | 31 | 15 | 60 | 11 | 11 |
| 39-40 | 17 | 24 | 33 | 29 | 44 | 61 | 57 | 25 | 11 | 47 | 7 | 12 |
| 41-42 | 18 | 10 | 18 | 25 | 45 | 50 | 45 | 11 | 3 | 28 | 3 | 10 |
| 43-44 | 5 | 1 | 6 | 7 | 14 | 24 | 38 | 6 | — | 14 | 1 | 6 |
| 45-46 | 3 | 1 | 5 | 5 | 9 | 10 | 14 | 4 | — | 9 | — | 2 |
| 47-48 | 2 | 1 | 3 | — | 3 | — | 4 | 1 | — | 3 | — | — |
| 49-50 | — | — | — | — | 2 | 1 | — | — | — | — | — | — |

$$l_{24} = 41.13 \left[ 1 - e^{-0.34\ (24 - 4.24)} \right]$$

$$= 41.08 \text{ mm.}$$

During all the months of the first year males showed only one conspicuous mode except in January, 1968 when two modes are seen at 25 - 26 and 29 - 30 mm respectively (Table LI). In April, 1967, 25 - 26 mm was the only modal size which remained same in succeeding month also. But in June the mode increased to 27 - 28 mm. This dominent size was maintained, upto August and in September and October the mode progressed to 29 - 30 mm, beyond which the mode could not be traced. But in November a mode at 25 - 26 mm was noticed which in December 1967 increased to 27 - 28 mm. This mode could be traced to the next month in which the higher out of the two modes was at 29 - 30 mm. The smaller mode in January, 1968 at 25 - 26 mm did not progress in next month; but increased to next size group in March. During the next year of study the single modes were recognised in all the months (Table LII). The mode at 25 - 26 mm in April 1968 increased to 29 - 30 mm in October showing an increase in carapace length by 4 mm during 5 months.

The progression of modes as traced in a sequential manner and the mean values of each month for male show that there is an average increase of 2 mm in carapace length from 25.5 to 27.5 mm during the period of one month. Since growth during the earlier period should be at a higher rate it is likely that these prawns grow to a size of 25.5 mm carapace length within 8 months. Therefore it is seen that they attain a length of 27.5 mm in 12 months and 29.5 mm in 14 months.

## LENGTH FREQUENCY DATA OF *P. SEMISULCATUS*

1967 - 1968

| Size groups | No. of males taken per month in each size group | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Apr. | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. |
| 19-20 | 1 | 1 | — | 2 | — | — | — | — | — | 2 | — | 2 |
| 21-22 | 8 | 22 | 4 | — | 4 | 1 | 5 | 7 | 5 | 4 | 1 | 8 |
| 23-24 | 51 | 69 | 31 | 14 | 12 | 20 | 16 | 13 | 30 | 27 | 29 | 35 |
| 25-26 | 132 | 71 | 99 | 52 | 66 | 55 | 72 | 92 | 58 | 63 | 82 | 95 |
| 27-28 | 96 | 47 | 103 | 83 | 127 | 98 | 85 | 81 | 140 | 40 | 61 | 128 |
| 29-30 | 33 | 27 | 31 | 82 | 62 | 120 | 92 | 58 | 53 | 72 | 20 | 39 |
| 31-32 | 4 | 5 | 8 | 18 | 16 | 32 | 32 | 45 | 29 | 35 | 5 | 5 |
| 33-34 | 3 | 1 | — | 6 | 3 | 5 | 4 | 10 | 9 | 5 | 2 | 2 |
| 35-36 | 1 | — | — | 2 | 1 | 2 | — | — | 7 | — | — | 1 |
| 37-38 | — | — | — | — | 1 | 2 | — | — | — | — | — | — |
| 39-40 | — | — | — | — | 1 | — | 1 | — | — | — | — | 2 |

[redacted]

1968 - 1969

| Size groups | No. of males taken per month in each size group | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Apr. | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. |
| 19-20 | — | — | — | — | — | — | — | — | 2 | 3 | — | 1 |
| 21-22 | 9 | 27 | 10 | 2 | 6 | 4 | 2 | 13 | 8 | 13 | 4 | 15 |
| 23-24 | 56 | 58 | 50 | 24 | 26 | 19 | 13 | 26 | 41 | 24 | 34 | 63 |
| 25-26 | 87 | 115 | 175 | 92 | 58 | 53 | 58 | 37 | 76 | 55 | 76 | 100 |
| 27-28 | 72 | 69 | 194 | 142 | 119 | 104 | 85 | 38 | 82 | 115 | 88 | 65 |
| 29-30 | 26 | 27 | 71 | 47 | 75 | 67 | 98 | 49 | 45 | 105 | 39 | 39 |
| 31-32 | 3 | 4 | 24 | 8 | 16 | 16 | 11 | 41 | 35 | 42 | 22 | 7 |
| 33-34 | 1 | — | 2 | 1 | 1 | 1 | 1 | 33 | 29 | 10 | 20 | — |
| 35-36 | 1 | — | — | 1 | — | — | — | 6 | 13 | — | 7 | — |
| 37-38 | 1 | 1 | — | — | 1 | 2 | — | — | 5 | 1 | 7 | — |
| 39-40 | — | — | — | — | — | — | — | — | 3 | — | 5 | — |
| 41-42 | — | — | — | — | — | — | — | — | 2 | — | 3 | — |
| 43-44 | — | — | — | — | — | — | — | — | — | — | 1 | — |

The computed values are as follows:

$b = 0.749$ and $a = 7.380$

Therefore $K = -\log e; b = 0.288$

$$l = \frac{a}{1-b} = \frac{7.380}{1-0.749} = 29.5 \text{ mm}$$

The estimated values are:

Sum $t = 63$; $n = 6$ and $\frac{1}{K}\left[\log e\,(1 - l_t/l_\infty)\right] = -5.203$

Therefore, $t_o = \frac{63}{6} - 5.20$

$= 10.50 - 5.20 = 5.30$

Applying Bertalanffy's equation,

$l_{12}$ (length at age 12 months)

$$= 29.5\left[1 - e^{-0.288\,(12 - 5.3)}\right]$$

$= 26.2$ mm

$l_{24}$ (length at age 24 months)

$$= 29.5\left[1 - e^{-0.288\,(24 - 5.3)}\right]$$

$= 29.36$ mm

Thus it is seen that males of P. semisulcatus attains carapace length of 26.2 mm at the age of one year and 29.36 mm at the completion of two years while the females which are larger than males, reach carapace lengths of 38.16 mm in one [illegible] year and 41.08 mm at two years of age. These values agree well with the lengths for corresponding ages arrived at by the analysis of modes of different months.

The length frequency data shows that (1) the size groups above 45 - 46 mm are represented by females on (2) females formed the higher

sizes in the samples examined during the various months (3) the first year-class has a size range greater than the second year-class (4) overlapping of various sizes exists and (5) July to October had more larger size groups than other months.

## LENGTH/WEIGHT RELATIONSHIP

According to Le Cren (1951) the length-weight relationship is calculated, (1) for determining the mathematical relationship between length and weight so that one could be calculated if the other is known and (2) to measure the variations from the expected weight of individuals or groups as indications of fatness, general well-being or gonad development. Therefore, the length-weight relationship of P. semiulcatus was determined.

It has been shown that the weight of a fish is a function of length as an increase in length of fish result in increase of weight also. Since length is a linear measure while weight is a measure of volume, the relation between length and weight could be expressed, in the case of fishes, by the hypothetical cube law, $W = aL^3$, where 'W' is the weight of the fish, 'L' its length and (a) a constant. But Le Cren (on.cit.) has suggested that it is better to fit the general parabolic equation. $W = aL^n$, expressing the relation between the two factors better than the cubic formula where 'W' and 'L' are weight and length of fish respectively 'a' a constant equevalent to 'c' and 'n' a constant to be computed empirically.

The weight will be proportional to the cube of any linear dimension if there is no change in form or density, as the animal grows. The coefficient of regression of logarithm of weight on logarithm of length often depart considerably from 3.0 with increase in age, due to changes in morphology. The value of the exponent 'n' in the parabolic equation lies usually between 2.5 and 4.0 (Hile, 1936, Martin, 1949), while Beverton and Holt (1957) is of opinion that important departures from 3.0 are rare. Balckburn (1960) found that the value of 'n' was much less than 3.0 in the case of Australian barracouta. Therefore, in the present study it was tried to fit in the general equation.

Before using carapace length as a measure of growth of a particular species it is essential first, to find its relationship to total length. So, specimens were measured for total length and carapace length, making sure that only complete specimens were selected. The carapace lengths were arranged in 2 mm groups and the average plotted against average total lengths (Pl.XX The relationship was found to be a straight line by the method of least square. The relation of total length to carapace length was T = 3.2 - 231 + 3.4802 C, where T is total length and C, carapace length. There has been no significant allometric growth in either sex in respect of these two characters and therefore carapace length alone was taken into account for the present studies whereever length is involved.

Carapace length was measured to the nearest millimeter from the posterior margin of the orbit to the posterior end of the carapace in the middorsal line. Carapace length had a definite advantage over the total length in that, the measurements could be very accurate, unlike the total length which may vary atleast slightly depending on the extend of straightening of the prawn. The weight was taken in grams for each specimen. The above method was uniformly adopted throughout the two years of the study. During April 1967 to March 1968 759 prawns (366 females ranging in carapace length from 22 to 49 mm and 393 males varying in length from 15 to 38 mm) and during April 1968 to March 1969, 512 prawns (260 females ranging from 24 to 50 mm in length and 252 males of size range 19 to 46 mm) from Mandapam were taken for this study.

The general parabolic equation $W = aL^n$, can be written as log $W = \log a + n \log L$ which is in the same form as the equation $Y = A + B X$, where 'A' corresponds to log a; 'B' to n; 'Y' to log W and 'X' to log L. This linear equation was applied in the case of data collected during the two

RAW SUM OF SQUARES AND PRODUCTS

Females

1967

| Months | n | Sum X | Sum Y | Sum XY | Sum $X^2$ | Sum $Y^2$ |
|---|---|---|---|---|---|---|
| June | 32 | 17.8919 | 49.9591 | 28.0301 | 10.0505 | 78.3050 |
| July | 26 | 14.6094 | 39.8245 | 22.5486 | 8.2720 | 61.4359 |
| August | 19 | 10.1774 | 28.1183 | 15.1508 | 5.4921 | 41.8356 |
| September | 33 | 18.5882 | 51.2920 | 29.2054 | 10.5921 | 80.5585 |
| October | 32 | 16.6351 | 46.8315 | 24.3814 | 8.6670 | 68.6480 |

TABLE LIV

CORRECTED SUM OF SQUARES AND PRODUCTS

| Months | d.f. | $x^2$ | xy | $y^2$ | B | Sum of squares | d.f. |
|---|---|---|---|---|---|---|---|
| June | 31 | 0.0468 | 0.1081 | 0.3702 | 2.3098 | 0.1205 | 30 |
| July | 25 | 0.0630 | 0.1712 | 0.4363 | 2.7174 | 0.3898 | 24 |
| August | 18 | 0.0405 | 0.0892 | 0.2230 | 2.2025 | 0.0268 | 17 |
| September | 32 | 0.1218 | 0.3118 | 0.8352 | 2.5599 | 0.0370 | 31 |
| October | 31 | 0.0193 | 0.0362 | 0.1108 | 1.8756 | 0.1040 | 30 |
| | 137 | 0.2914 | 0.7165 | 1.9755 | 2.4588 | 0.6971 | 136 |

years separately for the both sexes. The values of parameters 'A' and 'B' were calculated by the method of least square. The raw sum of squares and products of log length - log weight data for females during the various months of the year 1967 - 1968 are given in Table LIII. The table LIV gives the corrected sum of squares and products as well as the regression coefficient 'B' for each case and the deviation from regression.

Analysis of covariance was employed to test whether the regressions of Y and X are significantly different in the different months of the first year as given in Table LV and it was found that there was no significance in the regression coefficient. Hence the data for the entire year were pooled and the combined length-weight relationship was fitted for each year.

TABLE LV

ANALYSIS OF COVARIANCE

| Source of Variation | d.f. | Sum of Squares | Mean Squares | F |
|---|---|---|---|---|
| Deviation from individual regressions | 132 | 0.6778 | 0.0051 | 1.06 Not significant |
| Difference between regressions | 4 | 0.0193 | 0.0048 | (Value from the Table at 5% level 5.56) |
| Deviation from average regressions | 136 | 0.6971 | | |

Similarly, analysis of covariance was employed to determine whether there was any significant difference between the regressions of Y and X for the two sexes for the year 1967-68. Tables LVI-LVIII present the data showing that it was significant at 5% level. Therefore, a general relation between

1967 - 1968

| Sex | No.of prawns | Sum X | Sum Y | Sum XY | Sum $X^2$ | Sum $Y^2$ |
|---|---|---|---|---|---|---|
| Males | 393 | 169.6171 | 484.8761 | 214.1367 | 74.8533 | 616.1896 |
| Females | 366 | 194.4622 | 540.6870 | 290.6460 | 104.7112 | 808.2966 |

TABLE LVII

CORRECTED SUM OF SQUARES AND PRODUCTS

| Sex | d.f. | $x^2$ | $y^2$ | xy | B | Sum of squares | d.f. |
|---|---|---|---|---|---|---|---|
| Males | 392 | 1.6473 | 17.9585 | 4.8663 | 2.9541 | 3.5829 | 391 |
| Females | 365 | 1.3900 | 9.5468 | 3.3696 | 2.4242 | 1.3783 | 364 |
| | 757 | 3.0373 | 27.5053 | 8.2359 | 2.7116 | 5.1729 | 756 |

Y (log W) and X (log L) were calculated for the two sexes separately for the two years.

TABLE LVIII

ANALYSIS OF COVARIANCE

| Source of variation | d.f. | Sum of Squares | Mean Squares | F |
|---|---|---|---|---|
| Deviation from individual regressions | 755 | 4.9612 | 0.0066 | |
| Difference between regressions | 1 | 0.2117 | 0.2117 | 32.03 Significant (Value from table at 5% level 3.85) |
| Deviation from average regressions | 756 | 5.1729 | | |

The equations for the two years were found to be as follows:

Males: 1967-68 $W = 0.9093\ L^{2.9541}$

1968-69 $W = 0.9822\ L^{2.8953}$

Females: 1967-68 $W = 1.5492\ L^{2.4242}$

1968-69 $W = 1.2100\ L^{2.6536}$

The corresponding logrithemic equation may be represented as:

Males: 1967-68 $\log W = \bar{1}.9587 + 2.9541 \log L$

1968-69 $\log W = \bar{1}.9922 + 2.8953 \log L$

Females: 1967-68 $\log W = 0.1900 + 2.4242 \log L$

1968-69 $\log W = 0.0827 + 2.6536 \log L$

The observed values of length and weight of P. semiculeatus for the year 1967-68 were plotted (Pl.XX, 2 & 3) and curve fitted based on the calculated values. From the figure it can be seen that the curve fits

well with the scatter diagram. In the same way the logrithmic values of observed length and corresponding weights were plotted (Pl.XX, 2 & 3) and the straight line fitted which also clearly showed the linear relationship between the two variables.

Hall (1962) used the formula $W = kC^a$ where 'W' is weight and 'C' the carapace length, 'k', a constant and 'a' an exponent to be determined, and the length-weight relationship was calculated for P. semisulcatus from Singapore prawn ponds for a sample of 17 specimens and the formula arrived at was $W = 1.0069\ C^{2.727}$ which agrees with the formula obtained during the present studies, although the samples are from the open sea and the number of specimen observed much larger in comparison to that of Hall.

## RELATIVE CONDITION FACTOR

The length-weight relationship can be used to find out the variation from the expected weight for a length of individual fish or groups of fishes indicative of fatness (general well being) or gonad development which is termed as condition by Le Cren (1951). The changes in weight for length may be due to changes in form or volume and this change can be analysed by the condition factor or coefficient of condition or pounderal index (Hile, 1936; Thompson, 1943) which is given by the formula $K = \frac{100W}{L^3}$ where 'K' is the condition factor, 'W' the weight and 'L' the length of the fish respectively. This formula holds good only if the animal agrees with the cube law in its length-weight relationship. If the animal does not obey this law of an ideal fish the value of 'K' will change. Factors like age, sex, maturity, racial differences, food supply, degree of parasitisation environment and method of sampling may also affect the value of 'K' indirectly through the value of the exponent. These factors

could be eliminated by using an empirical length-weight relationship calculated using the formula $W = aL^n$ (Le Cren, op.cit.). This condition factor is called the relative condition factor 'Kn' and is given by the formula $Kn = W/aL^n$. This is the same as $Kn = W/\overline{W}$ where 'W' is the observed weight and $\overline{W}$ calculated weight. The condition factor (K) gives the deviation of an individual from the average weight for length while the relative condition factor (Kn) measurers the deviation from a hypothetical ideal from.

The relative condition factor 'Kn' was calculated for P.semiculatus by the above method. The length-weight data of 366 females and 393 males from Mandapam (Palk Bay and Gulf of Mannar) were made use of in the present study. The equation for females and males were found to be $W = 1.5492\ L^{2.4242}$ and $W = 0.9093\ L^{2.9541}$ respectively. The weights of all the specimens were calculated using these formula and the relative condition factor is given by the difference between the logarithmic equivalent of observed weight and the logarithmic equivalent of calculated weight. The geometric mean of 'Kn' was calculated for each month by taking the average of the above values.

The 'Kn' was calculated only for mature prawns as only very few immature specimens were encountered in the samples. The relative condition factor was determined for both sexes in different months and the mean values of 'Kn' was plotted for each month, (Pl.XX, 5). Similarly the mean values of 'Kn' was plotted against the carapace length (Pl.XX, 6).

Change in relative condition in different sizes:

The fluctuation in the relative condition with variation in lengths seems to be more or less same in both sexes. It is observed from the graph that the highest peak is at 21-24. The peak at 25-26 mm is not well marked.

But the through at 29-30 mm is quite clear. The highest peak at 21-22 mm indicates the increase in relative condition when males attain maturity. The subsequent peaks represent the cyclic gonadial development and spawning. In the case of females also a steep rise in the 'Kn' value, in the beginning followed by a similar descent is noticed. This is followed by peaks and troughs representing the cyclic gonadial changes.

This type of changes in the relative condition in the freshwater prawn Macrobrachium rosenbergii has been observed by Rao (1967) and in freshwater fishes by Pantalu (1962). It is known that factors other than spawning such as food, mainly affect the 'Kn' value. But in the case of prawn, the amount of food ingested is very little in comparison to the body weight that the food may not play an important role so as to affect the relative condition. Le Cren (1951) found that almost all seasonal fluctuation in the relative condition for mature and immature perch could be attributed to cyclic changes in gonad weight.

There are two peaks in the plot of relative condition values of mature prawns during different months with alternating troughs. In both sexes highest 'Kn' values are obtained in June which indicates that during this time the gonadial development takes place after attaining maturity. The sudden descend of the graph which follows the first peak denotes the post-spawning phase and spent condition. The second peak is indicative of the recovery in the condition which appears to be rapid (in December) in males than in females (in January). Thus it is shown that there are two peak spawning season during one year in the case of P. semisulcatus, one in June/July and other in December/January. This agrees with the conclusions arrived at by the studies on the maturity stages during the various months under study.

## REPRODUCTION

During the present studies about 100 specimens of P.semisulcatus were examined every month from the trawl catches landed at Mandapam, both from Palk Bay and Gulf of Mannar. In each sample the total length, carapace length, weight, sex and state of maturity of gonad were recorded. Specimens with broken rostrum or telson were not taken into account. The ovaries were removed and preserved in 5% formalin. The entire ovaries were carefully dissected out for fecundity studies while in other cases the anterior portion of the ovaries including the anterior and lateral lobes and a portion of the extension into the abdomen were preserved. It was observed that there was no appreciable shrinkage or swelling of the preserved ova in comparision with the fresh material.

The structure of the primary reproductive system of female P. semisulcatus agrees with that of the other penaeid prawns, Penaeus setiferus (King, 1948), Parapenaeopsis stylifera (Shaikmahmud and Tembe, 1958), Penaeus duorarum (Cummings, 1961), P.indicus (Subrahmanyam, 1965), P. orientalis (Oka and Shirahata, 1965), P. merguiensis (Tuma, 1967) and Metapenaeus dobsoni, M. affinis, P. indicus, Parapenaeopsis stylyfera (Rao, 1968). The ovaries consist of a pair of bilaterally symmetrical organs situated on the dorsal side of the prawn, extending from the base of the rostrum to the base of the telson. Each ovary comprises of an anterior lobe running forwards along the sides of the stomach and terminating near the base of the oesophagus, a middle region made up on 6-7 lateral lobes filling the cephalothoracic cavity above and on the side of the hepatopancreas and a posterior, much elongated lobe, running dorso-lateral to the gut, in the abdomen and turning ventrally near the telson fuse with the one on the other side. Posterior to the bases of the anterior lobes, the

ovaries are united. The oviduct arises from the lateral lobes, anterior to the posterior most lobes of the middle region and passing outwards turns down to open ventrally on the base of the third pair of perelopods.

The colour of the ovary changes as the process of maturation advances. The immature ovary is almost transparent while it becomes translucent or even light yellow during the early maturing stage. In the late maturing stage the ovary is green, almost filling the internal cavity and in the ripe condition it turns dark-green to greenish brown and fills up the entire body cavity.

Before taking a particular portion of the ovary for ova diameter measurements it was necessary to find out whether the distribution of the ova in the ovary was uniform. For this purpose the mature ovary of P. semisulcatus in late maturing stage from a specimen measuring 41 mm in carapace length was selected and portions of the right half of the ovary from anterior, middle and posterior regions were removed and teased on to microslides. The ova diameter measurements of ova in each portion were separately noted and the frequencies plotted (Table XX, 4). The frequency curves show a similar pattern of distribution for the three regions. The data for the three regions werepooled and plotted and since this also showed the same type of ova distribution, ova diameter measurements were taken from the middle lobes of one side only, to maintain uniformity. In order to study the maturity and to fix the spawning season, 2491 females and 1268 males were examined. The various stages in females were decided on macroscopic as well as microscopic examination of the gonads. Maturity studies of males were not undertaken as it was not possible to determine the various stages by macroscopic examination alone. However, all the males examined were mature.

The development of the ovary in P. semisulcatus was divided into five stages depending on the diameter and colour of the ovarian lobes and the size of the ova viz., stage I (immature or quiescent), stage II (early maturing), stage III (late maturing), stage IV (ripe or mature) and stage V (spent).

Stage I: Diameter of the ovarian lobes smaller than adjacent gut, translucent or white in colour. Ova uniformly small and transparent with clear nuclei. Ova measure 0.003-0.050 mm.

Stage II: Diameter of ovarian lobes same as that of the adjacent gut or a little more, translucent or white in colour. Majority of ova small, but some larger. Ova diameter vary from 0.167 - 0.184 mm.

Stage III: Diameter of ovarian lobes much larger than that of the gut, colour light to olive green. Ova distinctly of two sizes, i.e., larger ova with yolk and smaller ova as in stage II. Ova diameter range from 0.234 - 0.251 mm.

Stage IV: Diameter of ovarian lobes much larger than the diameter of the adjacent gut, filling almost the entire space inside the body cavity, in the abdomen and cephalothorax. Colour dark green or greenish brown. Majority of ova fully mature with rod-shaped bodies arranged radially in the cytoplasm around the periphery. Only few small sized ova. Ova measure 0.301-0.317 mm in diameter.

Stage V: Ovarian lobes flacid and much convoluted. Colour varies from cream to light yellow. Majority of ova small as in stage I while mature ova undergoing resorbtion present in varying numbers.

Development of ova to maturity:

Ova diameter measurements of 500 ova from a mature ovary were taken at random. The value of each micrometer division is 0.0167 mm. The ova diameter frequency polygon of a mature ovary (Pl.XX, 4) shows only one mode at 16 micro-divisions (0.267 mm) representing mature ova although there were smaller ova of the size found in stage I.

Ova diameter frequency polygons were drawn based on the measurements taken from ovaries in typical stages of maturity (Pl.XX, 7). In stage I ova of size range 0.033 - 0.100 mm were only present, while in stage II the only mode was noticed at 0.167 - 0.184 mm diameter, the range being from 0.117 - 0.217 mm. In stage III, the range is narrower being from 0.167 - 0.394 mm although the mode has progressed considerably reaching 0.234 - 0.251 mm. The modal ova size is 0.301 - 0.317 mm with a range in ova diameter from 0.200 - 0.484 mm. In spent stage, ova of sizes from 0.033 - 0.251 mm are observed, although, the sizes 0.067 - 0.084 mm and 0.167 - 0.184 mm dominated, the former being the larger mode.

Spawning:

Prawns, in general, breed more than once a year. In many species the late maturing and ripe stages occur in most of the months with peak occurrence during certain months. Thus it was shown that P. indicus has a prolonged breeding period on the west coast with greatest breeding activity from October and April (Panikkar and Menon, 1956; George, 1962; George et.al 1968 and Rao, 1968). In Madras waters Subramanyam (1963) reported this species to have a peak spawning season during March and May to September. Metapenaeus dobsoni and M. affinis also show a similar prolonged spawning activity with peaks of spawning in June, November to December and April in the former (Menon, 1951; 1955; Kesteven and Job, 1957; George, 1961; 1962; 1968 and Rao, 1968) and in the later spawning

season extends from October to March with a peak in December (Rao, 1968) or from October to December in the inshore area and from November to February in the offshore region (George, 1961; 1968). The same type of prolonged spawning habit is found in Parapenaeopsis stylifera. In Cochin area this species has peak spawning seasons in December and June to August (Rao, op.cit.) while in the Malabar coast it has been observed to breed during October to December (Menon, 1953) and in Bombay waters the intensity of spawning is recorded during March to May (Shikmahmud and Tembe, 1960).

In Penaeus semisulcatus it has been found that prawns with mature ovaries occur throughout the year indicating continous spawning habit although peak season is from June to September (Table LIX). The presence of prawns with ovaries in more than one stage of maturity in the same sample indicate that there is no periodicity in spawning.

In all, 1648 females during April, 1967 to March 1968 and 845 females during April, 1968 to March 1969 were examined to study the percentage occurrence of gonads in different stages of maturity. The details are presented in Tables LX - LXI.

In April, 1967 stages I - V were represented, although stage III were predominating (Pl.XX, 8). During May more females with ovaries in stage IV were encountered in the samples. In June percentage of ovaries in stage III was highest as also the subsequent months upto October. But in November stages III and IV were equally abundant. In December stage I was dominating. In January 1968 stage IV were more than other stages and in the subsequent two months stage III dominated. During March 1968 spent females were not recorded.

[redacted] OCCURRENCE OF MATURE PRAWNS (SPECIES III & IV)

| Months | 1967 - 1968 | | 1968 - 1969 | |
|---|---|---|---|---|
| | No. of prawns of all stages | Percentage of mature prawns | No. of prawns of all stages | Percentage of mature prawns |
| April | 88 | 65.91 | 119 | 75.63 |
| May | 81 | 55.56 | 89 | 64.04 |
| June | 80 | 83.75 | 106 | 80.08 |
| July | 229 | 86.46 | 43 | 86.05 |
| August | 122 | 75.41 | 59 | 88.14 |
| September | 94 | 78.72 | 55 | 89.47 |
| October | 151 | 77.48 | 59 | 57.63 |
| November | 107 | 52.34 | 57 | 56.14 |
| December | 174 | 19.54 | 54 | 48.15 |
| January | 195 | 74.36 | 59 | 71.19 |
| February | 195 | 77.95 | 53 | 58.49 |
| March | 132 | 70.45 | 90 | 45.56 |

MONTHLY OCCURRENCE OF OVARIES OF *P. SEMISULCATUS* IN DIFFERENT STAGES OF MATURITY

1967 - 1968

| Months | I | II | III | IV | V |
|---|---|---|---|---|---|
| April | 9.09 | 18.18 | 37.50 | 28.41 | 6.82 |
| May | 12.35 | 20.99 | 8.64 | 46.91 | 11.11 |
| June | 16.25 | 11.25 | 52.50 | 18.75 | 1.25 |
| July | 3.95 | 9.17 | 76.41 | 10.04 | 0.44 |
| August | 6.74 | 11.47 | 63.11 | 12.29 | 7.38 |
| September | 2.13 | 17.02 | 60.64 | 18.08 | 2.13 |
| October | 6.62 | 8.61 | 48.34 | 29.14 | 7.28 |
| November | 20.56 | 21.49 | 26.17 | 26.17 | 5.61 |
| December | 59.19 | 12.64 | 18.97 | 0.57 | 8.62 |
| January | 5.64 | 17.95 | 28.72 | 45.64 | 2.05 |
| February | 4.62 | 16.41 | 48.72 | 29.23 | 9.03 |
| March | 7.58 | 21.97 | 39.12 | 33.33 | — |

MONTHLY OCCURRENCE OF OVARIES OF *P. SENEGALUS* IN DIFFERENT STAGES OF MATURITY

1968 - 1969

| Months | I | II | III | IV | V |
|---|---|---|---|---|---|
| April | 4.20 | 19.33 | 43.70 | 31.93 | 0.84 |
| May | 3.37 | 30.33 | 61.79 | 2.25 | 2.25 |
| June | 2.83 | 15.09 | 70.75 | 11.33 | — |
| July | — | — | 81.39 | 4.65 | — |
| August | — | 11.86 | 76.27 | 11.86 | — |
| September | — | 10.53 | 71.93 | 17.54 | — |
| October | 23.73 | 18.64 | 54.24 | 3.39 | — |
| November | 3.51 | 40.35 | 33.33 | 22.82 | — |
| December | 20.37 | 31.48 | 38.89 | 9.26 | — |
| January | 11.86 | 16.95 | 64.41 | 6.79 | — |
| February | 9.43 | 32.07 | 54.71 | 3.77 | — |
| March | 16.67 | 37.78 | 42.22 | 3.33 | — |

During the second year stage III females were dominating in most of the months (Pl.XX, 9). In April, 1968 ovaries in stage III formed 43.70% while stage IV was represented by only 31.93% and stage IV was less than 1%. In May ovaries of stage II were next in abundance to stage III, as in June and July. In July, August and September stage I ovaries were absent as also stage V. During October prawns with ovaries in stage I were second to those with stage III ovaries. In November stage II females were dominating in the samples. During the months of December, 1968, January, 1969, February and March, stages III and II were first and second in abundance. The percentage of stage IV ovaries were less during December 1968 to March 1969. There were no prawn of stage V in these months.

It is found from the above data that female prawns in different stages of maturity may be present in any month of the year. For instance, immature prawns (stage I) are found in all months, although, the percentage varied in different months. Similarly prawns with late maturing and ripe ovaries are also found in the samples of all months. Spent ones are represented in the samples during the months from April, 1967 to February, 1968 and April and May 1968. The occurrence of prawns with ovaries in late stages of maturity along with spent ones in most of the months during the period of two years from April 1967 to March 1969 indicates that maturation of the gonad from immature to ripe stages occur always resulting in a continous addition of mature prawn to the stock every month.

Males were found to be mature during all the months, indicated by the presence of spermatophore in the terminal ampules of the vas deferens. Detailed study on the percentage occurrence of various stages of maturity in male prawns could not be undertaken as it was not possible to fix the

various stages of maturity by macroscopic examination of the testes. Therefore, the terminal ampules of the vas deferens of small males were examined under microscope to know whether they have reached maturity. The white colour of the terminal ampules seen from outside at the bases of the 5th pereiopods is also indicative of the presence of spermatophore in them.

Frequency of spawning:

The occurrence of the females prawns in the late stages of maturation during all the months of the year indicate that these prawns are continous spawners. But the month-wise percentage occurrence of ripe females in the commercial catches show that the peak spawning seasons are from June to September and in January/February in both the years under investigation. Specimens with spent ovaries were encountered rarely in the samples examined. This may be due to the quick resorbtion of the residual eggs and immediate recovery to early maturing stage.

Gonado-somatic index:

The size of the ovary and the largest common ova diameter of the ovary are the two factors in determining the state of maturity of a prawn. But in P. semisulcatus there is clear overlapping of the weights of ovaries belonging to the various stages of maturity. It has been pointed out by several authors (June, 1953; Yuen, 1955 and others) that relative ovary weight (ovary weight x 100/weight of prawn) is more suitable to explain the state of maturity of fishes. For the present studies, P.semisulcatus collected from Mandapam (Palk Bay and Gulf of Mannar) during April 1967 to March 1969 were utilised. The weight of the individual prawns preserved

in 5% formalin were taken carefully as for the length-weight studies. The ovaries were carefully dissected out and weighed to the nearest milligram.

The relative ovary weight or the gonado-somatic index was calculated for each prawn employing the formula given above. This was done only for mature prawns as the number of immature ones was very less. It has been observed that the relative ovary weight of prawns with maturing and ripe ovaries (stages III and IV) show avariation from 2.2 - 13.2.

Although there was variation in the relative ovary weights in different months they did not seem to differ significantly from one another. This may be due to the prolonged spawning over many months which may not allow substantial change in the relative ovary weight, as in the case of fishes with restricted spawning seasons.

Size at first maturity

In order to determine the minimum size of P. semisulcatus at maturity 1648 females during the period April 1967 to March 1968 and 845 females, during the period April, 1968 to March 1969 were examined. Females of all stages of maturity were available except those in the spawning condition.

Prawns were grouped into 2 mm size classes and the percentage occurrence in various stages of maturity in these size groups was calculated. Prawns with ovaries in stage III, IV and V have been grouped under mature prawns while the stages I was considered as immature and stage II maturing for the purpose of calculating the size at first maturity.

The details are presented in Tables LXII - LXIII.

TABLE LXII

PERCENTAGE OCCURRENCE OF FEMALES IN DIFFERENT STAGES OF MATURITY IN THE VARIOUS SIZE GROUPS

1967 - 1968

| Size group | No. of prawns | Stages of maturity | | | | |
|---|---|---|---|---|---|---|
| | | I | II | III | IV | V |
| 21-22 | 8 | 100.00 | --- | --- | --- | --- |
| 23-24 | 21 | 85.71 | --- | 14.29 | --- | --- |
| 25-26 | 47 | 53.19 | 31.91 | 10.64 | 4.26 | --- |
| 27-28 | 95 | 43.16 | 21.05 | 17.89 | 15.79 | 2.11 |
| 29-30 | 162 | 39.65 | 16.66 | 27.17 | 18.52 | --- |
| 31-32 | 187 | 12.83 | 20.32 | 47.59 | 17.66 | 1.60 |
| 33-34 | 272 | 5.89 | 15.07 | 52.20 | 23.53 | 3.31 |
| 35-36 | 225 | 5.34 | 15.11 | 51.99 | 22.22 | 5.35 |
| 37-38 | 222 | 2.70 | 14.87 | 49.56 | 27.47 | 5.40 |
| 39-40 | 194 | 0.52 | 13.40 | 52.58 | 25.25 | 8.25 |
| 41-42 | 117 | 1.71 | 5.98 | 47.01 | 41.03 | 4.27 |
| 43-44 | 57 | --- | 5.26 | 52.63 | 38.59 | 3.52 |
| 45-46 | 25 | --- | 4.00 | 28.00 | 56.00 | 12.00 |
| 47-48 | 11 | --- | 9.09 | 27.27 | 54.55 | 9.09 |
| 49-50 | 3 | --- | --- | 33.33 | 33.33 | 33.33 |
| 51-52 | --- | --- | --- | --- | --- | --- |
| 53-54 | 2 | --- | 50.00 | --- | 50.00 | --- |

TABLE LXXII

PERCENTAGE OCCURRENCE OF FEMALES IN DIFFERENT STAGES OF MATURITY

IN THE VARIOUS SIZE GROUPS

1968 - 1969

| Size group | No. of prawns | Stages of maturity | | | | |
|---|---|---|---|---|---|---|
| | | I | II | III | IV | V |
| 17-18 | 2 | 100.00 | --- | --- | --- | --- |
| 19-20 | 1 | 100.00 | --- | --- | --- | --- |
| 21-22 | 11 | 100.00 | --- | --- | --- | --- |
| 23-24 | 26 | 73.07 | 26.93 | --- | --- | --- |
| 25-26 | 37 | 43.24 | 40.54 | 16.22 | --- | --- |
| 27-28 | 60 | 19.10 | 45.00 | 33.33 | 1.67 | --- |
| 29-30 | 77 | 5.19 | 42.86 | 49.35 | 2.60 | --- |
| 31-32 | 84 | 1.19 | 27.38 | 61.90 | 9.52 | --- |
| 33-34 | 108 | --- | 27.78 | 66.67 | 5.55 | --- |
| 35-36 | 120 | --- | 18.34 | 70.83 | 10.00 | 0.83 |
| 37-38 | 118 | --- | 14.41 | 68.64 | 16.95 | --- |
| 39-40 | 94 | --- | 10.64 | 63.83 | 25.53 | --- |
| 41-42 | 56 | --- | 7.14 | 66.07 | 25.00 | 1.79 |
| 43-44 | 21 | 4.76 | 9.52 | 57.14 | 23.81 | 4.76 |
| 45-46 | 24 | --- | 16.67 | 62.50 | 20.83 | --- |
| 47-48 | 5 | --- | --- | 40.00 | 60.00 | --- |
| 49-50 | 1 | --- | 100.00 | --- | --- | --- |

From Table LXII it could be seen that during the first year of study all females were with immature ovaries upto carapace length of 21-22 mm. Mature prawns were found to have carapace length above 23 mm. Spent prawns were recorded in the size groups of 27-28 mm and above. In the size groups of 25-26 and 27-28 the percentages of immature prawns were more than the mature ones while in sizes 29-30 mm and above mature females were dominating.

During the year April 1968- March 1969 females showed the same pattern of maturity as the previous year (Table LXV). Theywere immature upto the size of carapace length 22 mm and from 23 mm onwards maturing stages were found in the samples. In sizes 25-26 and 27-28 mm maturing females were more than mature ones while above this size mature prawns were dominating in number, the percentage being increased gradually upto 45-46 mm size.

The data for the two years were pooled and the percentage occurrence of mature prawns (stages III and IV) and average for two years for calculated (Table LXIV; Pl.XVIII, 7). It is seen from the table that in the size group 23-24 mm only 7.1% were mature. This percentage gradually increased and reached 75.63 at 33-34 mm carapace length. At size 47-48 mm this percentage reached the highest viz., 95.45 beyond which larger sizes were present in the sample of first year only. The spent individuals were encountered in the samples in the size group of 27-28 mm in the first year while during the next year they appeared in the size 35-36 mm. In both years at size 29-30 mm, above 45% and 50% of females were found mature in the first and second years respectively. In both years, over 80% of the female prawns were mature in the size group 35-36 mm. There is no rapid increase in the percentage of mature prawns as was noticed in some of the fishes. From the above data it is clear that although some prawns are found to be mature at the size of 23-24 mm

TABLE LXIV

PERCENTAGE OCCURRENCE OF MATURE FEMALES IN THE VARIOUS SIZE GROUPS

| Size group | 1967-68 | 1968-69 | Average |
|---|---|---|---|
| 23-24 | 14.29 | --- | 7.15 |
| 25-26 | 14.90 | 16.22 | 15.56 |
| 27-28 | 35.79 | 35.00 | 35.40 |
| 29-30 | 45.69 | 51.95 | 48.82 |
| 31-32 | 66.85 | 71.42 | 69.14 |
| 33-34 | 79.04 | 72.22 | 75.63 |
| 35-36 | 82.43 | 81.66 | 82.05 |
| 37-38 | 79.55 | 85.59 | 82.57 |
| 39-40 | 86.08 | 89.36 | 87.72 |
| 41-42 | 92.31 | 92.86 | 92.59 |
| 43-44 | 94.74 | 85.71 | 90.23 |
| 45-46 | 96.00 | 83.33 | 89.67 |
| 47-48 | 90.91 | 100.00 | 95.46 |
| 49-50 | 100.00 | --- | 50.00 |
| 53-54 | 50.00 | --- | 25.00 |

majority attain maturity only at about 31-32 mm size. From the table LIX it is seen that maximum number of females were found with mature ovaries during the months of June to September and January/February denoting the peak spawning period.

The males were all mature at sizes 17-18 mm which were the smallest size caught in the trawls. The various stages of maturity of males could not be determined as macroscopic examination did not reveal these stages clearly. Therefore, it is seen that the males reach maturity earlier than females.

Fecundity:

Fecundity is the number of ova spawn at a time. Since all the ova developed in the ovary of a prawn are spawned the count of mature eggs in a mature ovary gives the fecundity.

For this purpose the ovaries of mature prawns (in stage III & IV) collected from Mandapam during the two years were utilised. The ovaries of 18 prawns ranging in length from 35-44 mm in stage III and 20 prawns ranging in length from 29-46 mm in stage IV were examined. Since the ovaries extended upto the tip of the abdomen the complete ovaries were carefully dissected out from fresh specimens and preserved in 5% neutral formalin. The carapace length and weight of the prawn were noted. The ovaries were weighed to the nearest milligram after removing excess moisture with filter paper. A piece of the ovary from the one of the lateral lobes was separated and weighed. The entire ova in this piece were teased out into a plankton counting chamber and spread out uniformly. All the mature ova in this subsample were counted. The total number of ova in the entire ovary was estimated from this, by dividing the weight of the entire ovary by the weight of the piece taken from it and multiplying by the number of ova in

TABLE LXV

NUMBER OF MATURE OVA IN INDIVIDUALS OF *P. SEMISULCATUS*

Stage III

| Sl.No. | Carapace length (mm) | Weight of prawn (gm) | Weight of ovaries (gm) | Total No. of mature ova |
|---|---|---|---|---|
| 1. | 45 | 63.8 | 5.870 | 4,26,456 |
| 2. | 45 | 65.4 | 7.040 | 6,60,904 |
| 3. | 36 | 32.4 | 2.540 | 1,34,499 |
| 4. | 39 | 47.0 | 3.410 | 1,72,205 |
| 5. | 42 | 54.4 | 4.461 | 4,26,120 |
| 6. | 44 | 58.7 | 1.890 | 1,57,194 |
| 7. | 39 | 46.3 | 4.322 | 1,86,873 |
| 8. | 40 | 43.7 | 1.905 | 1,13,030 |
| 9. | 39 | 39.9 | 0.892 | 51,605 |
| 10. | 40 | 47.2 | 4.952 | 4,13,298 |
| 11. | 38 | 46.6 | 1.994 | 2,40,875 |
| 12. | 37 | 36.0 | 1.269 | 1,11,260 |
| 13. | 40 | 43.7 | 2.010 | 2,18,932 |
| 14. | 38 | 47.9 | 1.920 | 2,43,600 |
| 15. | 35 | 32.4 | 1.080 | 1,39,735 |
| 16. | 36 | 32.4 | 0.810 | 79,907 |
| 17. | 40 | 48.6 | 2.822 | 6,02,400 |
| 18. | 42 | 54.4 | 3.830 | 3,10,942 |

TABLE LXVI

NUMBER OF MATURE OVA IN INDIVIDUALS OF *P. SEMISULCATUS*

Stage IV

| Sl.No. | Carapace length (mm) | Weight of prawn (gm) | Weight of ovaries (gm) | Total No. of mature ova |
|---|---|---|---|---|
| 1. | 33 | 27.6 | 1.390 | 91,532 |
| 2. | 41 | 51.4 | 3.064 | 2,04,062 |
| 3. | 29 | 18.5 | 0.871 | 67,891 |
| 4. | 41 | 49.1 | 6.472 | 3,70,600 |
| 5. | 31 | 22.0 | 2.447 | 4,65,120 |
| 6. | 32 | 22.2 | 1.570 | 1,16,596 |
| 7. | 39 | 46.3 | 4.995 | 3,05,483 |
| 8. | 39 | 45.6 | 2.787 | 4,30,674 |
| 9. | 40 | 45.7 | 2.770 | 1,50,688 |
| 10. | 37 | 37.9 | 3.992 | 5,10,781 |
| 11. | 41 | 52.4 | 4.180 | 1,96,695 |
| 12. | 42 | 53.1 | 4.022 | 1,96,072 |
| 13. | 37 | 37.9 | 3.740 | 2,54,881 |
| 14. | 38 | 41.2 | 3.590 | 1,08,418 |
| 15. | 38 | 44.4 | 3.694 | 2,31,359 |
| 16. | 39 | 44.8 | 3.320 | 2,10,204 |
| 17. | 37 | 41.2 | 3.550 | 2,14,229 |
| 18. | 46 | 64.9 | 6.592 | 5,25,856 |
| 19. | 46 | 63.8 | 6.190 | 3,55,856 |
| 20. | 45 | 65.0 | 7.290 | 5,19,270 |

this sample piece. The details are given in Tables LXV, LXVI . The number of ova in each ovary varied from 51,605 to 6,02,400 in stage III (mean 2,60,546) and 67,891 to 6,60,904 in stage IV (mean 2,76,313) ovaries.

Since it is likely that an individual may spawn more than once a year, the actual number of eggs produced by a single prawn in one year cannot be estimated accurately. But the total number of ova estimated by the above method indicates the potential stock of eggs present in various individuals.

Relation between fecundity and length of prawn:

There was no correlation between the number of ova present in the prawn and its carapace length although definite relation was established in fishes (Clark, 1934 and Hickling, 1940). James (1967) found that the fecundity of individual fish of the same length varied considerably in the case of the ribbon fish Eupleurogrammus intermedius. Fecundity of 38 individuals of P. semiarmatus are plotted against their length (Pl.XVIII,6).

Relation between fecundity and weight of ovary:

No correlation could be established between the weight of the ovary and number of ova produced. This has been shown by the scatter digram (Pl.XVIII, 5) plotted with the number of eggs in the ovary against the weight of the ovary.

Relation between fecundity and weight of prawn:

In order to find out whether there is any relation between the weight of the prawn and the fecundity, the observed values were plotted into a scatter diagram. It was seen that the two sets of data did not show any relationship.

Sex ratio:

The sexes were separated in each sample before analysing for biological data. The ratio between the two sexes did not vary much from the typical 1 : 1. During certain months males were a little dominating in number while in others it was the females which were more. The percentage occurrences of sexes in different months of the two years under study are given in Table LXVII.

It is seen from the table that during the year April 1967 to March 1968 females were more than 50% of the samples in the months of May, June, July, 1967 and February, 1968, while in all the remaining months the males dominated. During the months of February, 1968 alone the presentage of females was above 60% where as males reached this percentage only in the months of November, 1969 and March 1968.

In the second year of observation the variation in the proportion between females and males was within 10%. Thus only in the months of May and December 1968 and February, 1969 the percentages of females were as high as 56. Similarly during June, 1968 alone about 58% of males were occurring in the samples examined.

The pooled data for the year 1967-68 showed that the percentage of females (48.14%) was less than males (51.86%). During the second year (1968-69) the females dominated, registering 51.92% as against 48.08% males.

SEX RATIO OF *P. SEMISULCATUS* IN THE COMMERCIAL CATCHES

| Months | 1967 - 1968 | | | 1968 - 1969 | | |
|---|---|---|---|---|---|---|
| | Total no.of prawn | Percentage of females | Percentage of males | Total no.of prawn | Percentage of females | Percentage of males |
| April | 559 | 41.14 | 58.86 | 581 | 55.94 | 44.06 |
| May | 515 | 52.82 | 47.18 | 763 | 56.62 | 43.38 |
| June | 577 | 52.17 | 47.83 | 903 | 41.75 | 58.25 |
| July | 582 | 55.50 | 44.50 | 624 | 49.20 | 50.80 |
| August | 541 | 45.84 | 54.60 | 611 | 50.57 | 49.40 |
| September | 646 | 48.14 | 51.86 | 594 | 55.22 | 44.78 |
| October | 593 | 48.23 | 51.77 | 616 | 54.87 | 45.13 |
| November | 510 | 40.00 | 60.00 | 512 | 52.54 | 47.46 |
| December | 639 | 48.20 | 51.80 | 777 | 56.11 | 43.89 |
| January | 454 | 45.37 | 44.63 | 753 | 51.13 | 48.87 |
| February | 524 | 61.83 | 38.17 | 704 | 56.53 | 43.47 |
| March | 501 | 36.72 | 63.28 | 540 | 44.44 | 55.56 |

## DEVELOPMENT OF EXTERNAL GENITALIA

The development of external genitalia of P. semisulcatus was traced based on the study of specimens of various sizes from the smallest avilable specimens to the attainment of maturity. The process in general agreed with that of other penaeid prawns reported by Heldt (1938), Dunkenroad (1939) Kubo (1949) and George and Rao (1969).

The smallest male specimen examined during the present studies had a carapace length of 8 mm. At this stage, the endopods of the first pereopods have already developed a small, thin and elongated process 0.5 mm long and 0.1 mm broad, with maximum breadth being at about the middle. The distal end is narrower and rounded bearing two setae one of which is more than double the length of the other. Besides, there are three more setae situated at about the middle of the process, increasing in size from the proximal end of the series (Pl.III, fig.1). George and Rao (op.cit.) did not find any such distal setae in P. indicus although Kubo (op.cit.) reported similar apical setae in P. monodon. At 10 mm carapace length the petasmal process is about 0.6 mm long becoming broader at the middle. The terminal end is pointed bearing only a single long seta. At the middle there are only two short and strong setae (Pl.III, fig.2).

In the next stage at 14 mm carapace length the median and lateral lobes are demarcated by shallow longitudinal grooves with the distal margins of the lateral lobes getting divided into small lobes which mark the begining of the formation of dorsal and ventral lobules (Pl.III, fig.3). The development of petasma in P. semisulcatus at this stage agrees well with that of its congener described by George and Rao (op.cit.). As the prawn attains 17 mm length the tips of ventral lobules fold inwards and distal end of the median lobes recurve

over-hanging the outer lobes. At this stage the well developed lateral lobes, their tips more curved than before (Pl.III, fig.4) develop small hooks on the inner margin of the median lobe which has a median extension posteriorly.

At 23 mm carapace length the median lobes are more elongated with fully developed hooks (Pl.III, fig.5) and the two halves of the petasma get maximum curvature and the separating ridges between the dorsal and ventral lobules are more developed. The further development involves only increase in size as the prawn grows.

Thelycum. The general pattern of the process of development of this secondary sexual organ is more or less same as in the other species of the genus Penaeus (Kubo, op.cit) George and Rao, Op.cit.). The smallest specimen examined during the investigation measuring 8 mm in length has the median plate of the thelycum defined in the form of a roughly triangular piece situated on the 7th thoracic sternite, having a median elevation and the elongated sides extending laterally between the bases of the 4th and 5th pereopods (Pl.III, fig.7). The lateral plates form a V-shaped structure posterior to this, with a wide gap between the two plates on the anterior side. At 10 mm length the median plate becomes more triangular with a slight concavity on its posterior surface, the anterior elevation becoming more pronounced. The lateral plates remain more or less in the shape as in the previous stage (Pl.III, fig.8).

In specimen measuring 13 mm the anterior elevation of anterior plate is more rounded. At this stage the posterior median extension from the anterior plate makes its appearance. The lateral plates have expanded considerably towards the midventral line reducing the gap between them. Posteriorly these plates come to be very close to each other (Pl.III, fig.9). In the subsequent stages at 15 mm and 19 mm the posterior extension of the thelycal

becomes further developed with the anterior margin remaining in the shape as before (Pl.III, figs.10 & 11). The lateral plates expand towards the midventral line reducing the cavity in between and finally coming in contact with each other. When the prawn attains 23 mm, the plate becomes smoothly rounded, anteriorly. The lateral plates meet ventrally almost along its entire length leaving a narrow gap near the end (Pl.III, fig.12). Further the thelycum increases in size as the grows in length. The edges of the lateral plates curve upwards after along the middle and becomes fleshy and lamellate (Pl.III, fig.13).

with the development of external genitalia in Metapenaeus burkenroadi.

The development of petasma and thelycum in Metapenaeus burkenroadi with that of P. semisulcatus in general except in minor details. The of M. burkenroadi probably originates in the same manner as in monoceros. When the prawn attains 6 mm carapace length the lateral lobes folded slightly inwards showing the begining of the dorsal and ventral (Pl.III, fig.14). The rudiment of the posterior projection on the lobe develops posteriorly as in the case of M. monoceros (George and op.cit.). By the time the prawn reaches 8 mm the lateral lobes are distinctly demarcated and the posterior projection enlarges further. At length the petasma almost reaches the adult structure with well developed lobes and lobules (Pl.III, fig.19).

During the development of the thelycum the median plate at 7 mm is in the form of a median longitudinal, spindle-shaped piece with anterior half, tapering towards the anterior end while the posterior is rounded and situated between the bases of the 4th pair of pereopods.

The lateral thelycal plates are fused posteriorly in the middle with diverging anterior tips (Pl.III, fig.21). In the next stage the median plate becomes narrower at about its middle and the lateral plates remain in the same shape (Pl.III, fig.22). During further development the anterior plate gets rounded anteriorly while the anterior extremities of the lateral plates become pointed and posteriorly broadened, the hooks on the median margins also are developed and finally the adult condition is attained. The thelycum increases in size as in P. semisulcatus when the prawn grows further and fills the space between the 4th and 5th pairs of pereopods.

## PARASITES

During the analysis of the samples and observations in the field special care was taken to note the presence of any parasitic infection, external or internal. Some prawns were found to be parasitised by the bopyrid ectoparasite Epipenaeon ingens, Nobili while others were found to be infected by a microsporidian sporozoan Thelohania sp. The percentage of incidence and the effect on the host and thus on the stock, if any, was also studied. These species are reported from the Indian waters for the first time.

Nobili (1906) described Epipenaeon ingens from Red Sea parasitising Penaeus ashiaka, Kishinouye. The present studies from the Palk Bay and Gulf of Mannar have shown that P. semisulcatus alone was infested by this parasite among many other species of penaeid prawns occurring along with this species. The same condition was observed by Dawson (1958) in the allied species E. elegans, from the Persian Gulf. Chopra (1923) also reported E. elegans from Penaeus carinatus and P. semisulcatus. The percentage occurrence of this parasite was found to be same in specimens from Palk Bay and Gulf of Mannar.

E. ingens was found to occur in the branchial chambers of the prawns, usually in pairs, the small male clinging to the ventral surface of the abdomen of the large female. The branchial chamber of the prawn developed a characteristic bulging to accommodate the parasites which completely filled this chamber.

The female parasites exhibited a size range of 12.85 to 24.15 mm. The males collected during the present studies measured 4.25 to 7.75 mm in

total length. The hosts were found to be within the length range of 25 to 40 mm, in carapace length Table XLVIIa, XLVIIb. There are no correlation between the sizes of the hosts and parasites. Besides, the occurrence of *P.indicus* during most of the months indicated that the parasites could breed and thrive well in all the seasons of the year.

The percentage of infection of these parasites was more in females than in males (Table XLVIIc). During the first year of observation the percentage incidence of the parasite was higher in females during the months April, June, September, October and December, 1967, the maximum being in last month. Only in March 1968 a higher incidence was recorded for male hosts. Similarly, in the year 1968-69, the incidence registered during all the months in which the parasites were observed was higher in females except in December 1968 and January 1969. The percentage incidence ranged from 0.19 to 2.75 in males and 0.23 to 4.55 in females.

All the specimens examined exhibited degeneration of the gonads. In females none had ovaries in late stages of development, beyond stage II, which indicated that due to the infection the hosts could not attain full development of their ovaries irrespective of the seasons. Besides, the parasites which completely filled the branchial chamber produced pressure on the gills, reducing the effiecency of respiration. Although the infection does not cause immediate death it would definitely check proper growth and thus make parasitised prawns weaker resulting in earlier death.

Descriptions: Female: Body large, oval, longer than broad, only slightly asymmetrical. Head distinct from thorax and prolonged into narrow lamina,

anteriorly. Eyes rudimentary. Thoracic somites well marked with clearly defined demarcating lines, epimera of these somites being highly developed with rounded outer margins.

Abdomen one-third of total length, with less developed pleural lamellae and without tubercles on the dorsal surface. Only five abdominal somites visible dorsally with paired biramous pleopods. Uropod biramous. Rami of abdominal appendages covered with warts and tubercles.

Males: Body elongated twice as long as broad. Head small, distinct from thorax. Eyes extremely reduced. Antennules three segmented. Thoracic somites distinct with deeply notched lateral margins, first two pairs of lateral margins being directed anteriorly while other extending laterally.

Abdominal somites fused completely to form a subtriangular structure. No trace of pleopods or uropods.

This species could be distinguished from E. elegans Chopra and E. japonicus Thielemann, by the different body proportions. In E.elegans the body is almost as long as broad while in E.ingens and E. japonicus it is longer than broad. Although E. ingens and E. japonicus are closely related they differ in the nature of the frontal lamina, the pleural lamellae of abdomen, the dorsal surface of abdomen and the depth of the lateral notches of the thoracic segments of males. In E. ingens the frontal lamina is very small unlike that of E. japonicus. Similarly, the oreal surface of the abdomen is without tubercles in E. ingens as against tuberculate dorsal surface of abdomen in E. japonicus. Besides, the pleural lamellae in E. ingens are poorly developed; bat in E. japonicus they are well developed. The thoracic segments ofmale have deep notches on the outer side in E. ingens whereas they are not deeply notched in E. japonicus.

TABLE XLVIIa

Percentage incidence of *E. ingens* on *P. semimolestus* in various size groups.

April 1967 - March 1968

| Size groups | Apr. | May | Jun. | July | Aug. | Sep. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 25-26 | 0.63 | — | 0.94 | — | — | — | — | — | 1.33 | — | — | — |
| 27-28 | — | — | 0.83 | — | — | — | — | — | 0.54 | — | — | — |
| 29-30 | 2.73 | — | — | — | — | — | — | — | 4.27 | — | — | — |
| 31-32 | — | — | — | — | — | 2.08 | — | — | 5.68 | — | — | — |
| 33-34 | — | — | — | — | — | — | — | — | 1.72 | — | — | 3.23 |
| 35-36 | — | — | — | — | — | — | — | — | 33.33 | — | — | 7.14 |
| 37-38 | — | — | — | — | 1.92 | — | — | — | 6.67 | — | — | 10.53 |
| 39-40 | — | — | — | — | — | — | 1.72 | — | 8.33 | — | — | — |
| 41-42 | — | — | — | — | — | — | — | — | 33.33 | — | — | — |
| 45-46 | — | — | — | — | — | 1.25 | — | — | — | — | — | — |
| 47-48 | — | — | 0.33 | — | — | — | — | — | — | — | — | — |

Percentage incidence of *P. insons* on *P. semirelictus* in various size groups.

April 1968 - March 1969

| Size groups | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 25-26 | — | — | 0.54 | — | — | — | — | — | 0.05 | — | 0.06 | — |
| 27-28 | — | — | — | — | — | — | — | — | 0.06 | — | — | — |
| 29-30 | — | — | 0.94 | — | — | — | — | — | — | — | — | 2.78 |
| 31-32 | — | — | — | — | — | — | — | — | — | 1.22 | 3.45 | — |
| 33-34 | — | — | — | — | — | — | — | — | 1.61 | 3.92 | — | — |
| 35-36 | — | — | — | 2.33 | — | 1.96 | — | — | 2.86 | — | — | 6.25 |
| 37-38 | — | — | — | — | — | — | — | — | 5.00 | — | — | — |
| 43-44 | — | — | — | — | — | — | — | — | — | — | — | 16.67 |

TABLE XLVIIe

Percentage incidence of *E.insens* in relation to the sex of the host

| Months | No.of male Prawns | Percentage of parasites | No.of female Prawns | Percentage of parasites |
|---|---|---|---|---|
| April 1967 - March 1968 | | | | |
| April | 329 | — | 230 | 1.30 |
| May | 243 | — | 272 | — |
| June | 276 | 0.36 | 301 | 0.66 |
| July | 259 | — | 323 | — |
| August | 293 | 0.34 | 248 | — |
| September | 234 | 0.30 | 311 | 0.32 |
| October | 307 | — | 286 | 0.35 |
| November | 306 | — | 204 | — |
| December | 331 | 2.72 | 308 | 4.55 |
| January | 248 | — | 206 | — |
| February | 200 | — | 324 | — |
| March | 317 | 0.95 | 184 | 0.55 |
| April 1968 - March 1969 | | | | |
| April | 256 | — | 325 | — |
| May | 331 | — | 432 | — |
| June | 526 | 0.19 | 377 | 0.27 |
| July | 317 | 0.32 | 307 | — |
| August | 302 | — | 309 | — |
| September | 266 | — | 328 | 0.30 |
| October | 278 | — | 338 | — |
| November | 243 | — | 269 | — |
| December | 341 | 1.17 | 436 | 0.23 |
| January | 368 | 0.82 | 385 | — |
| February | 306 | — | 398 | — |
| March | 300 | — | 240 | 1.68 |

Some of the specimens of P. semiculcatus were whitish in colour with milky white flesh and internal organs. On close examination it was found that they were heavily infected by a sporozoan parasite. The colour was quite distinguishing and microscopical examination of muscles and gonads revealed the presence of Thelohania sp. The tissues were found to be full of the parasites in different stages of the life-cycle.

It has been known that microsporidian parasites cause similar conditions known as 'milk shrimp' or 'cotton shrimp' in the pink shrimp, Penaeus duorarum (Iversen and Manning 1959), brown shrimp, P. aztecus and white shrimp, P. setiferus from Barataria Bay, Louisiana (Sprague, 1950) and Boca Ciega Bay, Florida (Hutton, et.al. 1959). There has been no published record of any microsporidian parasites of prawns from the Indian Region. This is the first report of the genus from species of penaeid prawns occurring in Indian waters.

Although the parasites seems to differ from all the known species the identity of this could not be fixed as all attempts to bring out the polar filament failed.

Description: The spores of Thelohania sp. were ovoid (Pl.XXI) the spore membranes unstriated and with a clear round area representing the vacuole towards the broader end. No polar capsules were present. The protoplasm appeared to be of granular nature. The spores measured 4.5 to 5.5 $\mu$ in length and 3.13 to 3.75 $\mu$ in breadth. The pansporoblasts were rounded (Pl.XXI) measuring 8-13 $\mu$ in diameter. Each of these pansporoblasts had eight spore of same size enclosed in the membrane which is characteristic of the genus Thelohania.

The present species resembles T. ducrara Iveresn and Manning in the general shape and larger size of the spores and pansporoblasts. But the pansporoblasts of the present material are more or less spherical while they are oblong in T. ducrara. Moreover, Thelohania sp. invade in entire musculature of the body, gonads, intestine and even nerve cord, thus differing from T. penaei Sprague which is found only in the ovary of Penaeus setiferus and from T. ducrara the site of infection of which is the musculature alone. The musculature of the body and legs of heavily infected prawns become milky white and opaque, lacking the firmness of healthy tissue. The ovaries contain no normal eggs and are white in colour. In late stages of infection all the internal organs are invaded and the prawns are unable to compete successfully with healthyones as a result of the decrease in the functional efficiency of the various infected organs.

In order to determine the rate of incidence of these parasites in the commercially important prawns of the locality 6641 and 7974 specimens of Penaeus semisulcatus which forms more than 99% of the total catch of prawn were examined during the two years 1967-68 and 1968-69 respectively, at random, from the trawler catches landed at Mandapam from the Palk Bay and the Gulf of Mannar. During the year 1967-68 the rate of infection was more in prawns from the Gulf of Mannar (1.31%) than from the Palk Bay (0.44%). But the percentage of infected prawns during the year 1968-69, was found to be more or less of the same order among prawns from Palk Bay and Gulf of Mannar. It was noted that more females were infected than males and the majority of infected ones belong to the larger size groups ranging in carapace length from 29 to 41 mm. Infected prawns were encountered during the months of September to December 1967 in the first year of observation whereas they occurred in July, October, December 1968 and March 1969

in the next year. The average percentage of incidence was higher (0.91%) in the year 1967-68 whereas it was about one-third (0.37%) during the year 1968-69.

The infection of these microsporidian parasites did not seem to affect the stock of Penaeus semisulcatus in the fishes grounds off Mandapam in Palk Bay and Gulf of Mannar as the percentage of incidence of these parasites was negligible in comparison with the fishable stock.

## FISHERY

Prawn fisheries play a very important role in the Indian economy due to the large amount of foriegn exchange earned as a result of the export of frozen and canned prawns. Eventhough, export of dried and semidried prawns existed much earlier, the present modern and sophisticated industry of frozen and canned prawns fetching over a million rupees a year is of recent origin. This industry which is concentrated in the southwest coast of India has resulted in the increased demand for fresh prawns. The regular functioning of the industry depends much on the supply of prawns from other part of the country as well.

Although prawns were caught even earlier in small numbers in the various indigenous gears used in the Gulf of Mannar and Palk Bay fishing for prawns by otter trawls using mechanised boats were started in this area, only very recently. About five years back the demand for fresh prawns was first felt here with the arrival of the agents of the freezing and canning industry from Cochin. The establishment of a boat building yard, fishermen training centre and ice-factory with enough cold storage facilities by Indo-Norwegian Project has contributed considerably to the development of prawn fishery to the present stage.

Fishing Seasons:

The fishing in Mandapam is unique in that, prawn fishery exists throughout the year, either in the Palk Bay or in the Gulf of Mannar depending on this season. From February/March to November/December fishing operations are possible only in the Palk Bay as strong winds previal over the Gulf of Mannar as a result of Southwest Monsoon. Similarly fishing is done only in the Gulf of Mannar during October/November to March/April due to the roughness of Palk Bay with the onset of the Northeast Monsoon.

In the major fishing centres of Rameswaram and Pamban on the Rameswaram Island also these seasons are followed. At Pamban mechanised boats go for fishing either in the Palk Bay or the Gulf of Mannar depending on the seasons and land in the same place. But in Rameswaram, fishing is possible only during the Palk Bay season, although during certain months mechanised boats operate from here even in the 'off season', if the conditions are favourable.

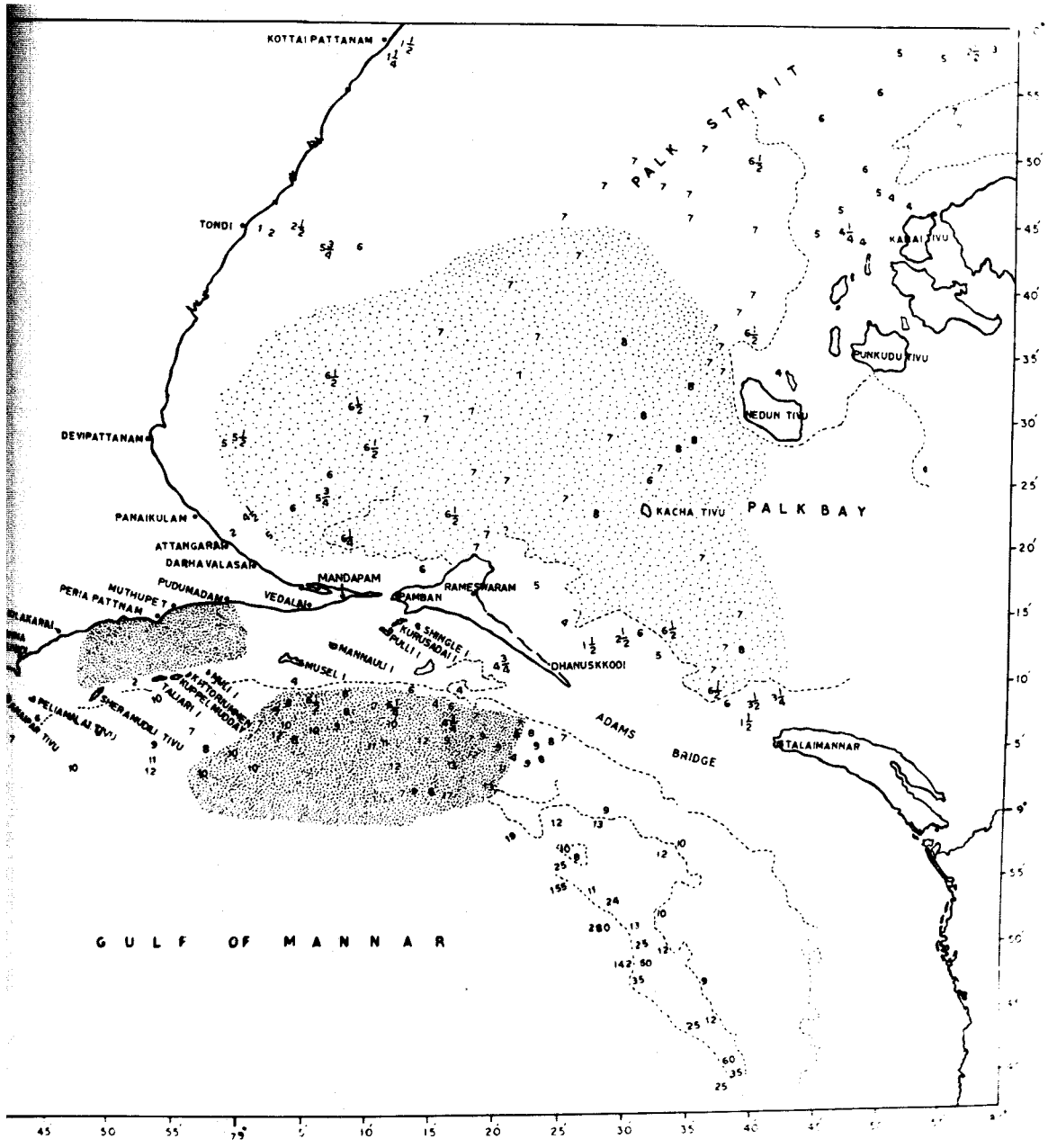
Fishing grounds:

In the Palk Bay boats from Mandapam and Pamban operate in the same grounds from 3 - 16 km off the coast. Some of the richest grounds exist off the estuary of Athankarai River and near Kacchatheevu. During the favourable season boats from Rameswaram may go for fishing as far as the neighbourhood of Delft Island (Map I,V). On the Gulf of Mannar side, fishing is more restricted to the inshore areas around the various islands which provide protection when the wind is strong. Some of the boats go far off to 'Thoondi Kadal' about 25 - 30 km where rich ground has been located.

Landings:

The data on the landings of prawns and fishes caught in the mechanised boats were collected based on random sampling method used by the Fishery Survey Division of the Central Marine Fisheries Research Institute and the figures for the years 1967-68 and 1968-69 are given (Table LXX). It is seen from the table that in the first two years of observation, prawn catches were better during the months, of April to July when fish landing were also more than the other months. Fish catches continued to be more during August and September of the same year although, there was a decline of prawn catches during this period. In the year 1968-69 the prawn catches as well as fish landings were good even during the month of August 1968. The prawn landings during the months of September and October 1968 were very poor although, the quantity of prawn caught

# MAP I




Southeast coast of India showing major collection centres and fishing grounds in Gulf of Mannar and Palk Bay.

LANDINGS OF PENAEUS SEMISULCATUS AT MANDAPAM DURING APRIL 1967 - MARCH 1969

| Months | 1967 - 68 | | | 1968 - 69 | | |
|---|---|---|---|---|---|---|
| | Penaeus semisulcatus | Others | % of total marine landings | Penaeus semisulcatus | Others | % of total marine landings |
| April | 2.62 | 1150.15 | 0.23 | 2.97 | 819.13 | 0.36 |
| May | 2.84 | 2100.46 | 0.14 | 9.92 | 1562.01 | 0.63 |
| June | 4.19 | 2291.91 | 0.14 | 9.03 | 2549.83 | 0.35 |
| July | 1.37 | 1417.20 | 0.10 | 4.50 | 1956.89 | 0.23 |
| August | 0.76 | 1780.75 | 0.04 | 1.22 | 1504.86 | 0.08 |
| September | 0.37 | 1204.79 | 0.03 | 0.25 | 252.82 | 0.10 |
| October | 0.47 | 1204.94 | 0.05 | 0.52 | 859.56 | 0.05 |
| November | 0.34 | 249.59 | 0.14 | 3.44 | 164.50 | 2.05 |
| December | --- | 17.51 | --- | 3.84 | 79.60 | 4.60 |
| January | 0.69 | 18.93 | 3.52 | 11.06 | 59.90 | 15.59 |
| February | 0.32 | 163.68 | 0.20 | 7.14 | 41.24 | 14.76 |
| March | 1.04 | 306.18 | 0.35 | 5.39 | 66.15 | 7.53 |

increased considerably in November and December, 1968 and in January 1969 it reached the maximum of 11.06 m.tons. The landing was declining during the last two months under observation.

Disposal of catches:

The prawns of each mechanised boat are sorted on board after each haul and kept separately either in wooden trays or baskets with or without ice. As soon as they reach the landing centre the prawns are collected by the merchants. They are thoroughly washed several times with fresh water and packed with crushed ice in baskets of palmyrah leaf. These are despatched to the processing factories in Cochin where they are quick-frozen or canned for shipment to foreign countries.

The discarded prawns are disposed off in the local markets at cheaper rates. The heads are dried and used as manure. Of late, the fresh and decayed heads of puwn prawn are in great demand for using as bait in fish traps.

Socio-economic considerations:

The price of these prawns of first quality may vary from Rs.6 to 12 per kg (head on) at the landing centre, depending on the demand in foreign markets. The merchants usually advance money to the boat owners and entitle themselves to the right of purchasing the prawns at a concessional rate, generally Re.0.50 less than the normal rate. These merchants may even supply free ice to be taken on board while going out for fishing. In order to save the commission of merchants some boat owners, send their catch direct to the agents in Cochin.

Most of the owners do not go for actual fishing; but engage trained fishermen, giving them monthly salary and a share of the catch or a little

higher percentage alone as an incentive for them to bring more catches. Many of the owners dry the silver bellies (leiognathids) and sell the fresh larger fishes to meet the day to day expenditure, so that, they are able to utilise the proceeds from prawn sales for remitting the monthly instalments towards the refund of loan which most people take for the purchase of the mechanised boats.

## SUMMARY

The results of the "Studies on the Indian Decapods" are embodied in the present thesis. The first part of the taxonomy of the group deals with the systematics of 31 species of penaeid prawns including all the economically important Indian species. There are 21 species of caridean shrimps of which some are of considerable economic importance as they constitute fisheries of varying magnitude in different parts of India. The 40 species of hermitcrabs described include almost all the shallow water species reported from the Indian Region, some new records and a few deep sea forms. The second part gives the details of the results of the investigations on the biology of the tiger prawn Penaeus semisulcatus and its fishery in the Gulf of Mannar and Palk Bay.

One genus of penaeid prawn viz. Trachypenaeopsis Burkenroad has been reported from the Indian Region for the first time and a new species, T. miniocrensis is described in detail. Besides, there are a number of new distributional records. Three species viz. Penaeus latisulcatus, Penaeus canaliculatus and Trachypenaeus curvirostris have been collected for the first time from the Laccadives while Penaeus canaliculatus, P. merguiensis, Metapenaeus lysianassa, M. dobsoni, M. affinis, M. burkenrodi and Parapenaeopsis cornuta are new records from Andaman and Nicobar Islands. Other newly reported species of penaeid prawns are Solenocera crassicornis, S. hextii, Metapenaeopsis stridulans, M. hilarula, Parapenaeopsis maxillipedo, P. cornuta and P. acclivirostris from the Gulf of Mannar and Penaeus japonicus, Metapenaeopsis stridulans, Metapenaeus lysianassa, M. brevicornis, Parapenaeopsis maxillipedo and P. cornuta from the Palk Bay.

There are a number of new records of caridean prawns and shrimps also. The palaemonid prawn Macrobrachium australe, the gnathophyllid

Penaeopsis elegans and the alpheid shrimps Alpheus rapax, A. sublucens, A. distinguendus and A. malabaricus gonadia are first records from the Indian Region. Macrobrachium rosenbergii, M. scabriculum are reported fro the first time from Mandapam area. Amphistylus quatuor, Parisolenocera brevicarpalis, Hippolysmata spinirostris and Latreutes mucronatus are new records to Palk Bay. Among the hermitcrabs Clibanarius longitarsus and Spiropagurus spongiabelloe are first reported from the west coast of India while Pagurus kulkarnii is a new record from east coast of India and Solenopus sculptidi, C. latens and Pagurus janitor are newly recorded from Andaman and Nicobar Islands. Besides, Clibanarius strigatus and Coenobita rugosus from Laccadive Archipelago, Spiropagurus spiriger from Coromandel Coast and Gulf of Mannar, Pagurixtes longicarpus, P. inermitatus, Clibanarius infrapinatus, Cl. nodaveneis, Cl. marginensis, Dardanus setifer and Diogenes obstatus from Palk Bay and Pagurixtes longicarpus, Clibanarius zebra, Spiropagurus spiriger, Coenobita rugosus and C. perlatus from the Gulf of Mannar are other new records.

The food and feeding habits of Penaeus semisulcatus have been studied in detail. These prawns were found to feed on polychaetes, crustaceans molluscs, diatoms, radiolarians pisces and foraminifera although considerable quantity of detritus was also found in the gut contents. It has been observed that prawns from the Gulf of Mannar feed on more molluscan material than those from Palk Bay, although other dietary components were the same in both areas. These prawns were found to be actively feeding during night as they were in the habit of getting themselves buried in the bottom during day time. Since the quantity of the individual food items varied considerably it was evident that they were not selective feeders. The abundance of a particular food item in the stomach was dependant on the availability of the

item in plenty during the particular season. The carnivorous habit of *P. semisulcatus* added support to the observations of other workers on other species of prawns.

*P. semisulcatus* has been found to live more than two years, females attaining 38.16 mm and 41.08 mm at the end of first and second years, respectively, while the sizes attained by the males at the ages of one and two years were 26.20 mm and 29.36 mm respectively. The rate of growth in the first year in females was found to be 3.5 mm per month whereas in males it was only 2 mm per month. As in other prawns the rate of growth in this species also decreased as they increasedin size.

The relationship between length and weight of *P. semisulcatus* was determined for both sexes, for the years 1967-68 and 1968-69. The formulae arrived at were as follows:

Males: 1967-68 - $W = 0.0993\ L^{2.9541}$

1968-69 - $W = 0.9822\ L^{2.8953}$

Females: 1967-68 - $W = 1.5492\ L^{2.4242}$

1968-69 - $W = 1.2100\ L^{2.6536}$

There was significant difference between the length/weight relation of male and female specimens.

The relative condition factor 'Kn' was calculated for males and females and the polygon of mean 'Kn' value and size showed clear peak at 21-22 mm and trough at 23-24 in males indicating the attainment of maturity at this size. In female prawns also the first peak and trough indicating maturation and subsequent peaks and troughs denoting cyclic gonadial development

and spawning were noticed. From the mean values of 'Em' in the various months it was found that there were two peak spawning seasons during an year, one in June/July and the other in December/January. This has been supported by the fact that peak occurrence of female prawns with ripe gonads coincides with these two seasons.

The gonado-somatic indices in these prawns were found to vary from 2.2 to 13.2. The size at first maturity in females was found to be 23-24 mm while the smallest sizes of males (17-18 mm) were found to be mature, indicating that the males attain maturity earlier than females.

The fecundity of P. semisulcatus ranged from 51,605 to 6,60,904. There was no definite relation between the fecundity and the weight of the prawn. Similarly no correlation could be established between the weight of the ovary and number of ova produced as also between fecundity and weight of prawns.

The sex-ratio did not vary much from the typical 1:1, although in certain months one of the sexes was found to be dominating.

P. semisulcatus was found to be infected by the microsporidian parasite Thelohania sp. causing the condition popularly known as 'White Shrimp' 'Cotton Shrimp' or 'Lime Shrimp'. The bopyrid parasite Epinnacon ingens was also observed to parasitise these prawns, exhibiting definite host specificity. But the very low percentage incidence indicated that they did not affect the population to any appreciable extend.

Prawn fishing in Palk Bay and Gulf of Mannar during the period of study was by flat type trawl nets operated by medium mechanised boats during night. The prawns after sorting and removal of head were packed with crushed

ice in palmyrah leaf-basket and despatched to the processing plants at Cochin or Madras. The prawn fishery has improved the economy of the area to a considerable extent.

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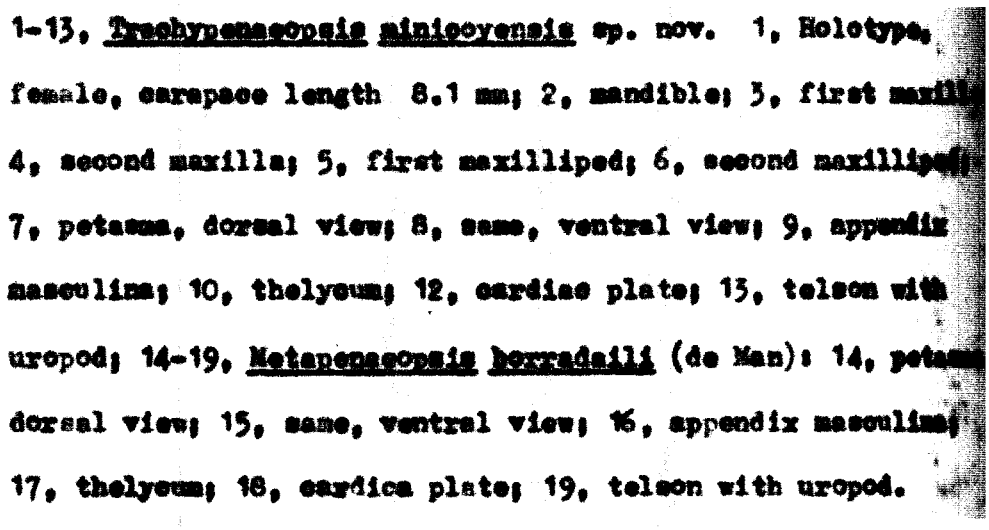
# PLATES

## PLATE I



1-13, *Trachypenaeopsis miniocyensis* sp. nov. 1, Holotype, female, carapace length 8.1 mm; 2, mandible; 3, first maxilla; 4, second maxilla; 5, first maxilliped; 6, second maxilliped; 7, petasma, dorsal view; 8, same, ventral view; 9, appendix masculina; 10, thelycum; 12, cardiac plate; 13, telson with uropod; 14-19, *Metapenaeopsis horradailli* (de Man): 14, petasma, dorsal view; 15, same, ventral view; 16, appendix masculina; 17, thelycum; 18, cardiac plate; 19, telson with uropod.

PLATE I

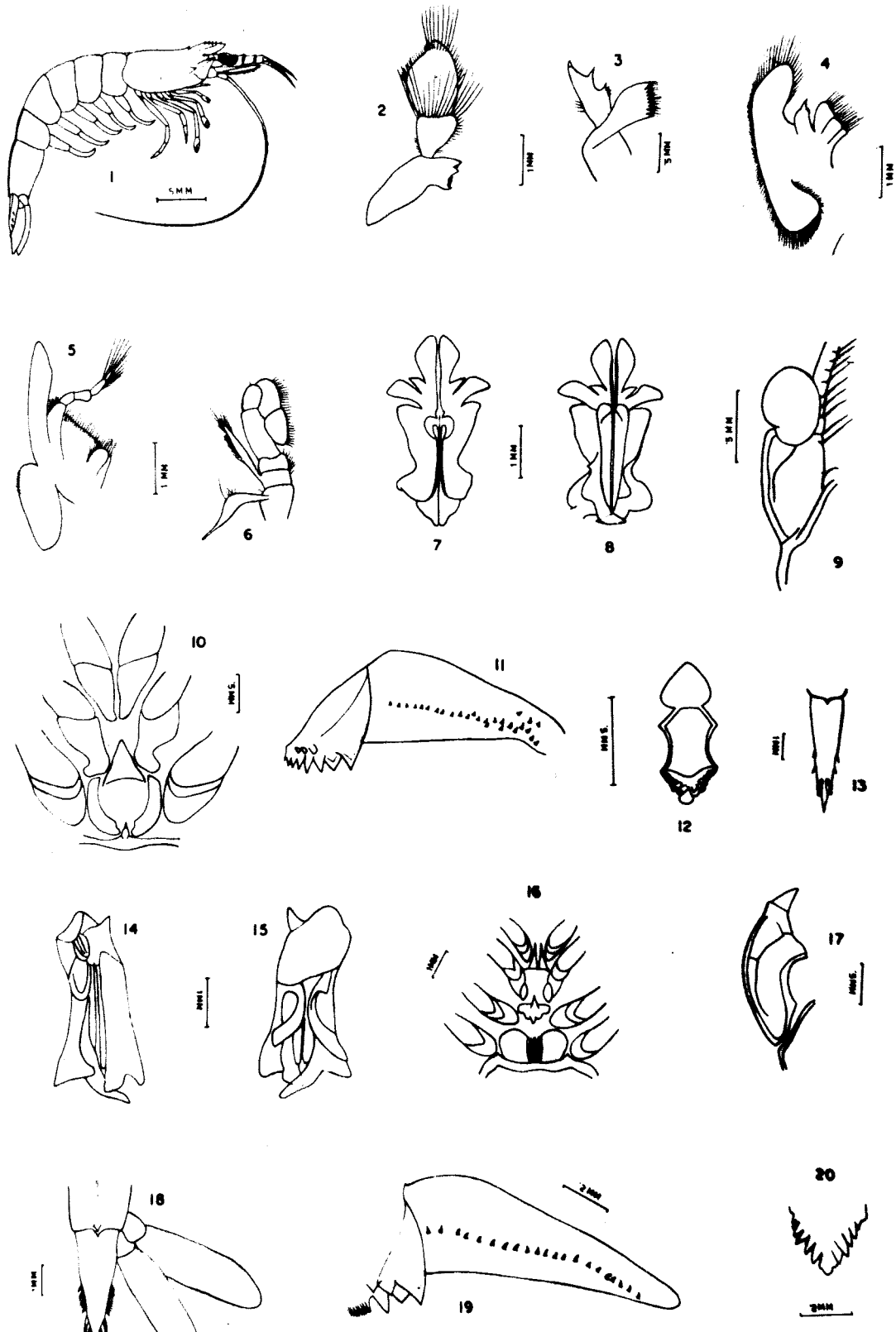

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PLATE II

*Metapenaeopsis hilarula*: 1, Pelasma, ventral view, 2, same, dorsal view; 3, thelycum; *Trachypenaeus pescadoreensis*: 4, petasma, ventral view; 5, same, dorsal view; 6, thelycum; 9, cardiac plate; 10, appendix masculina; *T. curvirostris*: 7, petasma, ventral view; 8, dorsal view; 12, appendix masculina; 11, same, distal piece enlarged; *Parapenaeopsis tenella*: 13, petasma, ventral view; 14, same, dorsal view; 15, thelycum; *P. acclivirostris*: 16, petasma, ventral view; 17, same, dorsal view; *P. uncta*: 18, petasma, ventral view; 19, same, dorsal view, 20, thelycum, 21tip of petasma enlarged.

PLATE II

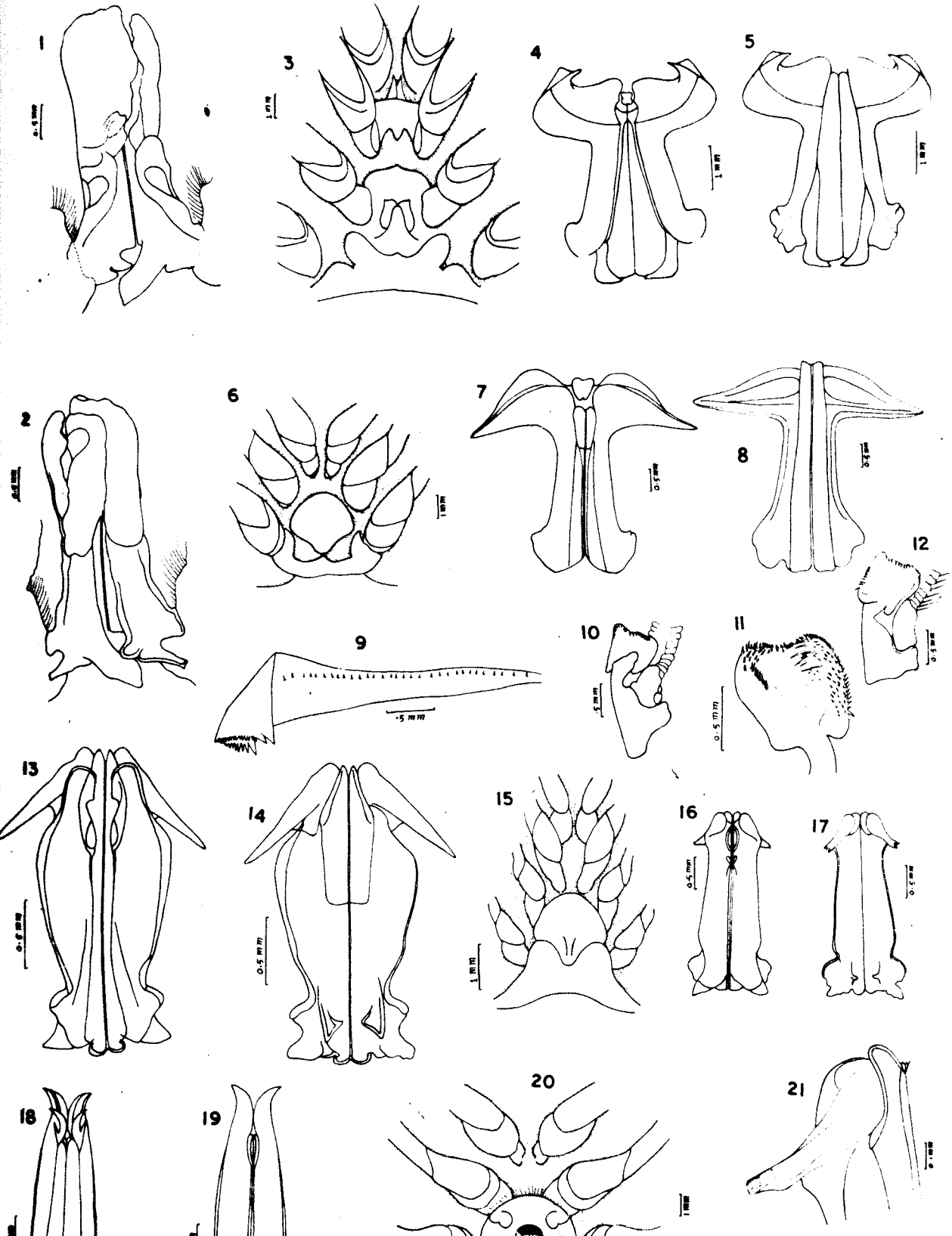
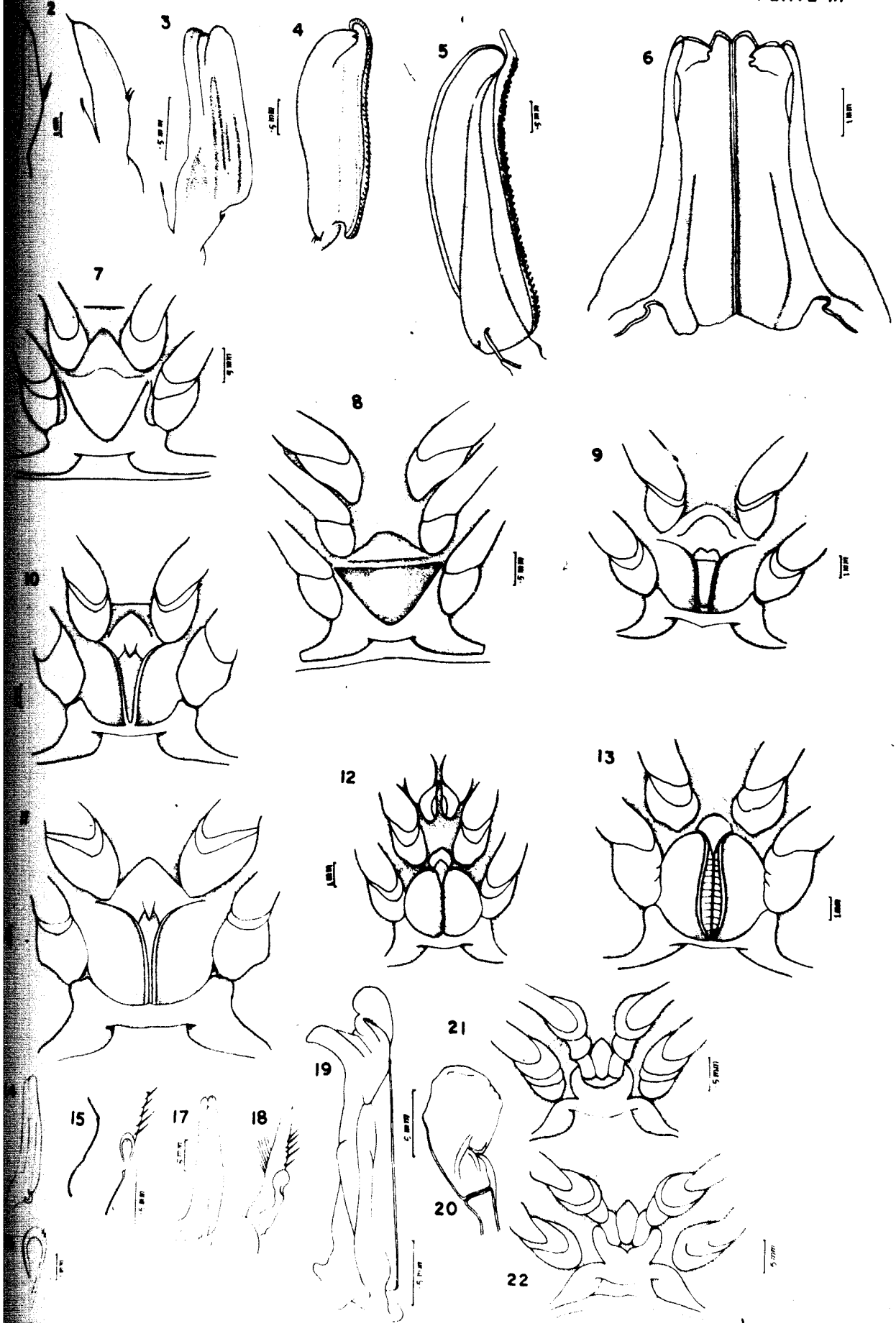


PLATE III

1-13, Penaeus semisulcatus: 1, Petasma of male 8 mm carap
2, same of male 10 mm; 3, same of mleas 14 mm; 4, same of
5, same of male 23 mm; 6, same of adult male 29 mm; 7, th
female 8 mm carapace length; 8, same of female 10 mm; 9,
female 13 mm; 10, same of female 15 mm; 11, same of fem
12, same of adult female 23 mm; 13, same of fully grown f
30 mm; 14-22, Metapenaeus burkenroadi: 14, petasma of mal
carapace length; 15, appendix masculina with base of end
enlarged; 17, petasma of male 8 mm; 18, appendix masculi
adult petasma; 20, adult appendix masculina; 21, thelyum
7 mm; 22, thelycum of female 9 mm.

PLATE III



## PLATE IV

1-3 *Anchistus custos*: 1, Antennal scale; 2, 3rd maxilliped; 3, tip of 3rd pereopod; 4-8, *Periclimenes brevicarpalis*: 4, Antennule; 5, Antennal scale; 6, 2nd pereopod; 7, 5th pereopod; 8, telson; 9-12, *Conchodytes tridacnae*: 9, antennule; 10, 3rd maxilliped; 11, tip of 3rd pereopod; 12, telson; 13-15, *Hippolyte ventricosa*; 13, antennal scale; 14, antennule; 15, 2nd pereopod; 16-18, *Latreutes pygmaeus*: 16, antennal scale; 17, antennule; 18, 3rd pereopod; 19-23, *L. mucronatus*: 19, antennule; 20, antennal scale; 21 berried female; 23, tip of telson; 24-27, *Hymenocera elegans*: 24 antennule; 25, antennae; 26, tail fan; 28-30, *Alpheus rapax*; 28, rostral front, dorsal view; 29, 2nd pereopod; 30, 3rd pereopod; 31-32, *A. distingue*[illegible] 31, 2nd pereopod; 32, 3rd pereopod; 33-34, *A. euphrosyne*: 33, 2nd p[illegible] 34, 3rd pereopod; 35-38, *A. malabaricus sonekla*: 35, large chela, i[illegible] view; 36, small chela inner view; 37, 2nd pereopod and 38, 3rd pere[illegible]

PLATE IV

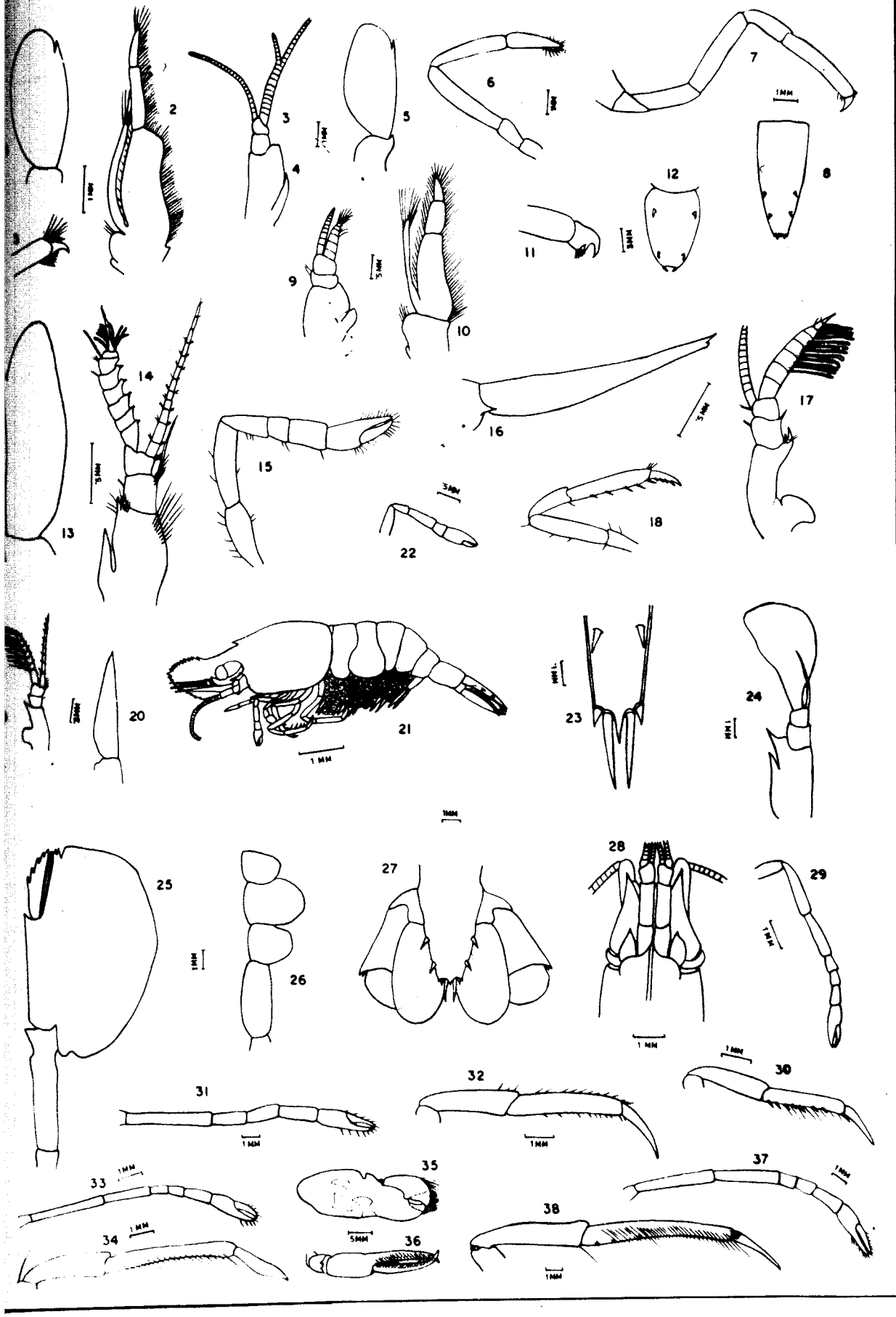

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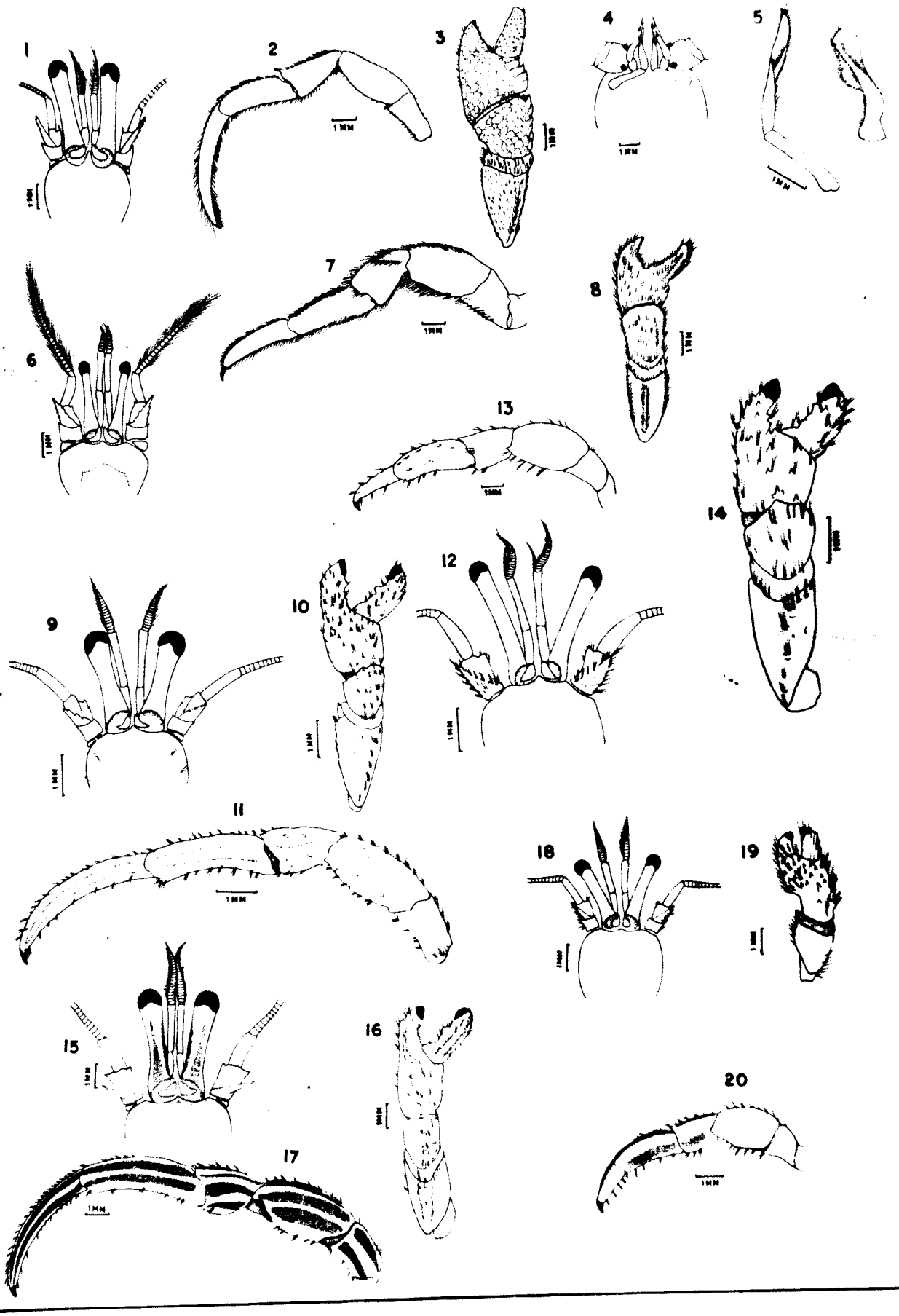
PLATE V

1-5, *Paguristes longirostris*: 1, Cephalic region and appendages; 2, 3rd leg; 3, large chela; 4, first two abdominal segments with paired appendages; 5, 1st and 2nd abdominal appendages magnified; 6-8, *P. incomitatus*: 6, cephalic region and appendages; 7, 3rd leg; 8, large chela; 9-11, *Clibanarius longitarsus*: 9, cephalic region and appendages; 10, large chela; 11, 3rd leg; 12-14, *Cl. marguiensis*: 12, cephalic region and appendages; 13, 3rd leg; 14, large chela; 15-17, *Cl. padavensis*: 15, cephalic region and appendages; 16, large chela; 17, 3rd leg; 18-20, *Cl. zebra*: 18, cephalic region wth appendages; 19, large chela; 20, 3rd leg.

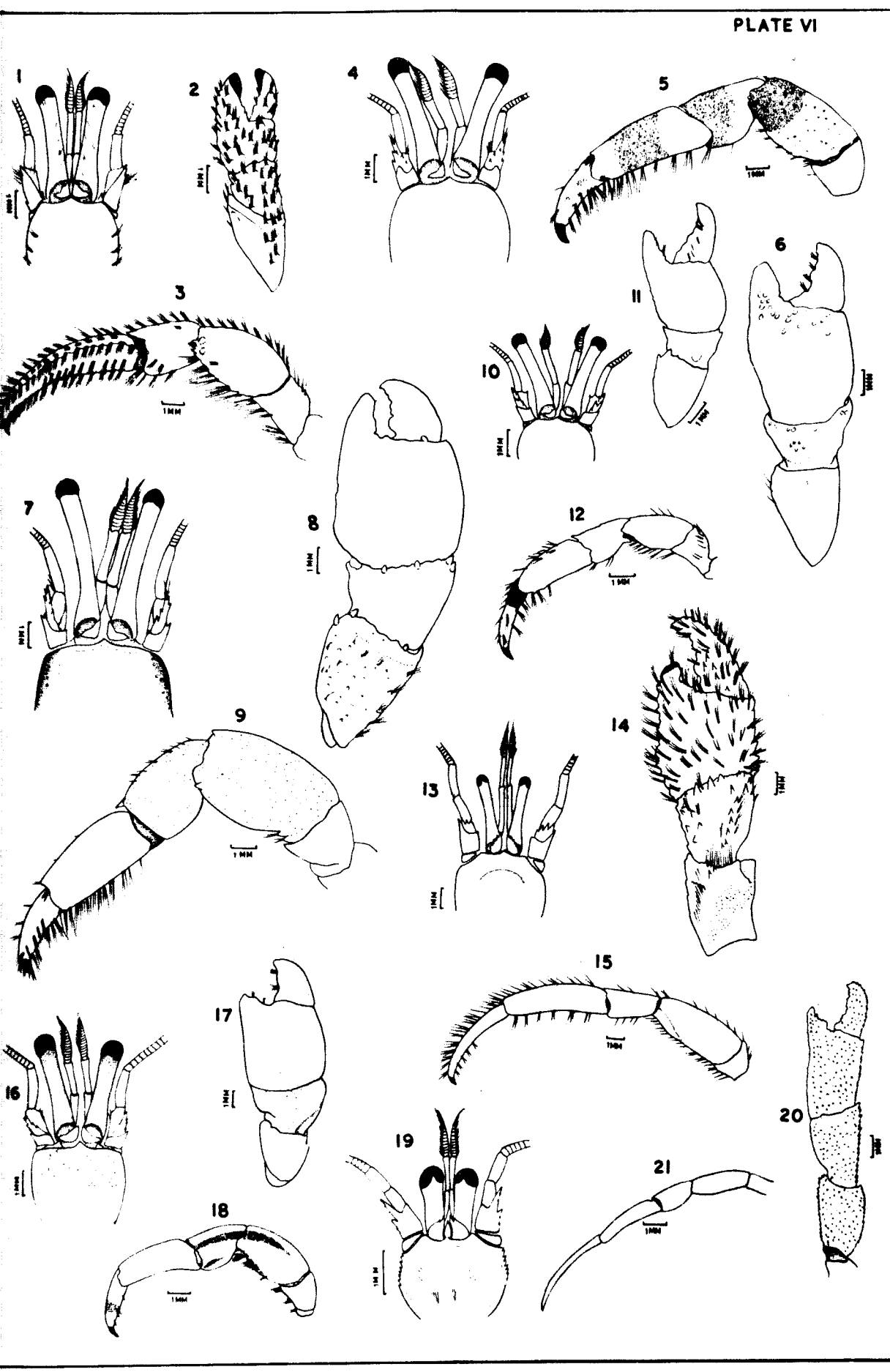
PLATE V



## PLATE VI

1-3, *Clibanarius corallinus*: 1, Cephalic region and appendages; 2, large chela; 3, 3rd leg; 4-6, *Calcinus elegans*: 4, cephalic region and appendages; 5, 3rd leg; 6, large chela; 7-9, *C. gaimardi*: 7, cephalic region and appendages; 11, large chela; 12, 3rd leg; 13-15, *Troglopagurus massarensis*: 13, cephalic region and appendages; 14, large chela; 15, 3rd leg; 16-18, *Calcinus herbstii*: 16, cephalic region and appendages; 17, large chela; 18, 3rd leg; 19-21, *Diogenes avarus*: 19, cephalic region and appendages; 20, large chela; 21, 3rd leg.

PLATE VI



## PLATE VII

1-3, *Clibanarius arethusa*: 1, Cephalic region and appendages; 2, large chela; 3, 3rd leg; 4-6, *Nematopagurus squamiochelles*: 4, cephalic region and appendages; 5, large chela; 6, 3rd leg; 7-9, *Diogenes costatus*: 7, cephalic region and appendages; 8, large chela; 9, 3rd leg; 10-12, *Nematopagurus indicus*: 10, cephalic region and appendages; 11, large chela; 12, 3rd leg; 13-15, *Diogenes investigatoris*: 13, cephalic region and appendages; 14, large chela; 15, 3rd leg; 16-18, *Pagurus kulkarnii*: 16, cephalic region and appendages; 17,large chela; 18, 3rd leg.

PLATE VII

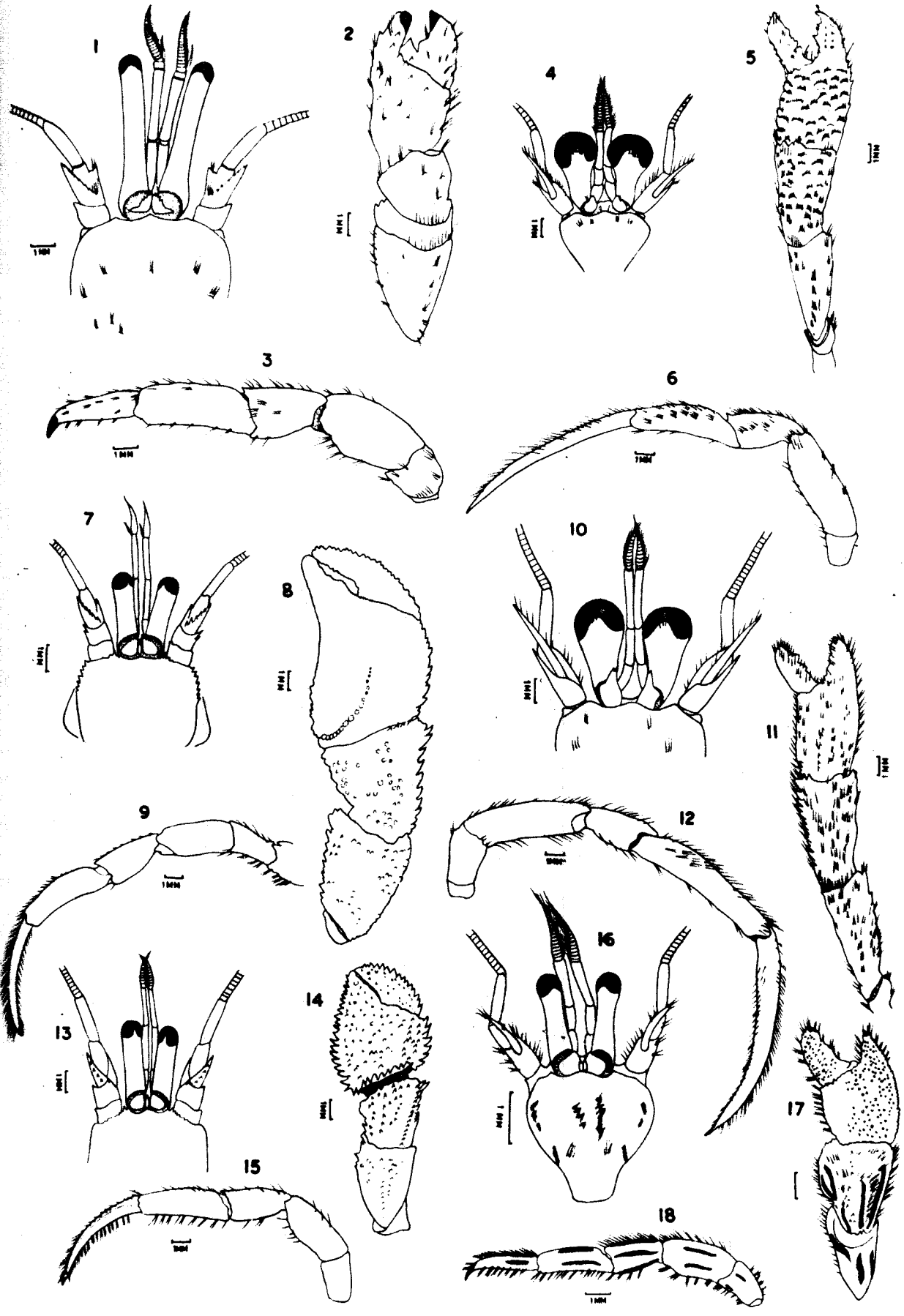
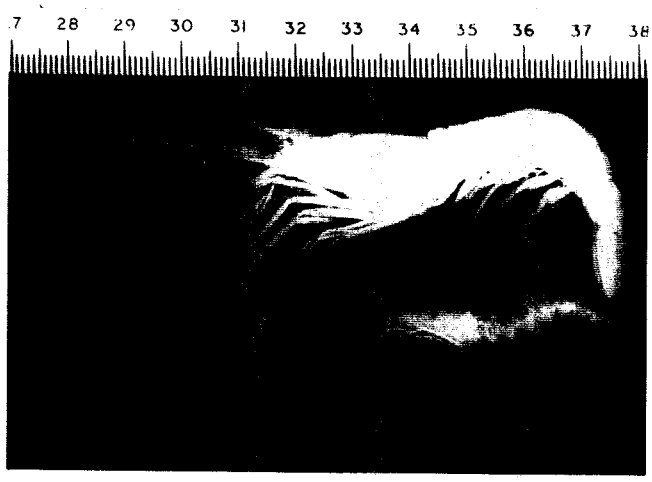


PLATE VIII

1. Solenocera crassicornis (Milne Edwards)
2. S. hextii Wood Mason
3. Penaeus latisulcatus Kishinouye
4. Metapenaeus lysianassa (de Man)
5. M. brevicornis (Milne Edwards)
6. M. dobsoni (Miers)

# PLATE VIII

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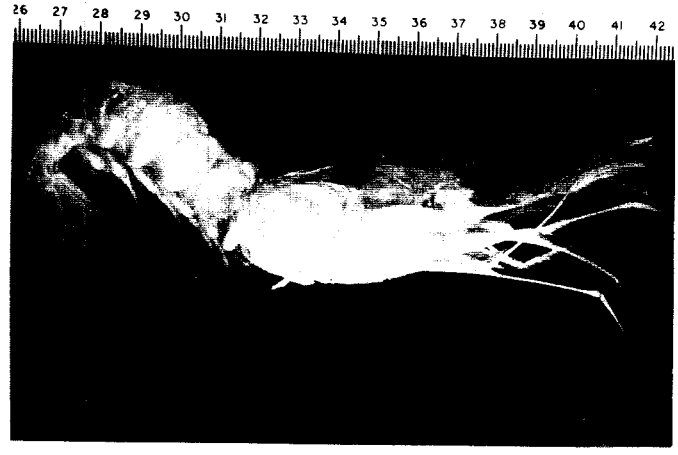


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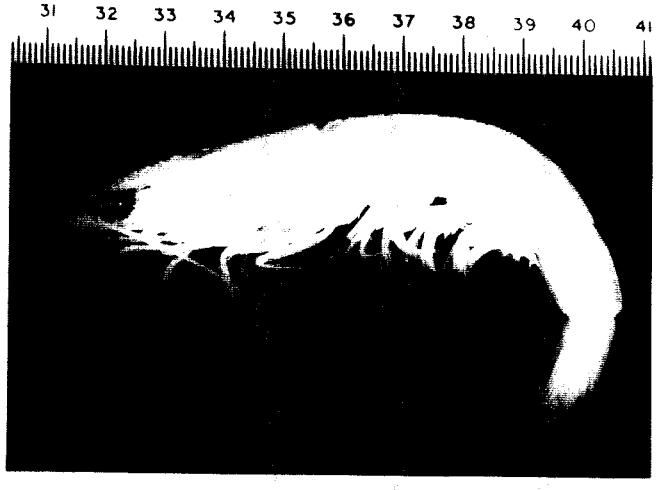


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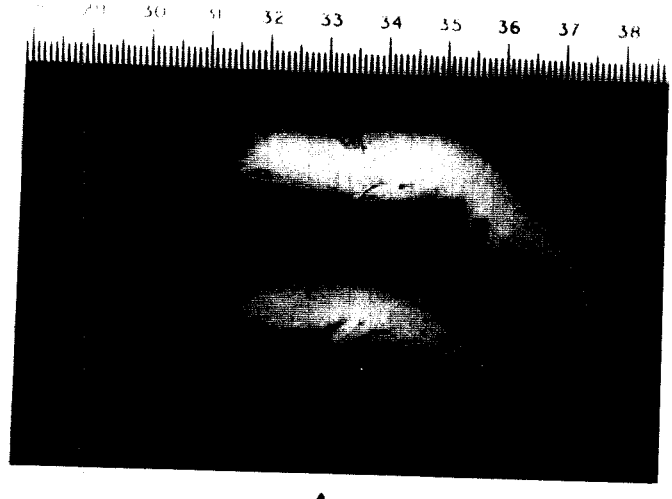



4

5

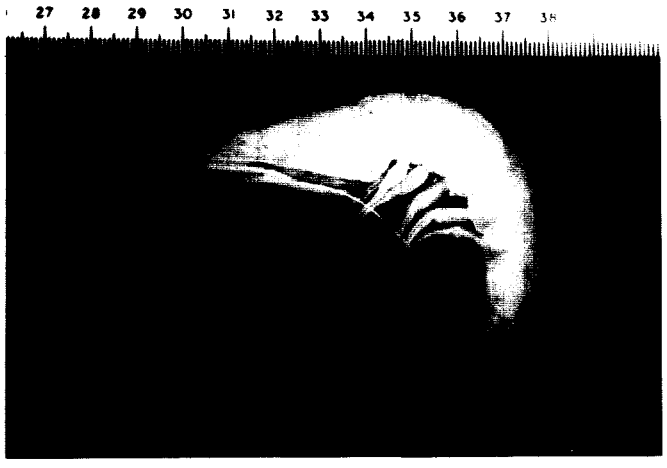
6

## PLATE IX

1. *Metapenaeus monoceros* (Fabricius)
2. *M. affinis* (Milne Edwards)
3. *M. burkenroad* Kubo
4. *Trachypenaeus pangadoreensis* Schmitt
5. *Parapenaeopsis uneta* (Alcock)
6. *P. stylifera* (Milne Edwards)

# PLATE IX

1



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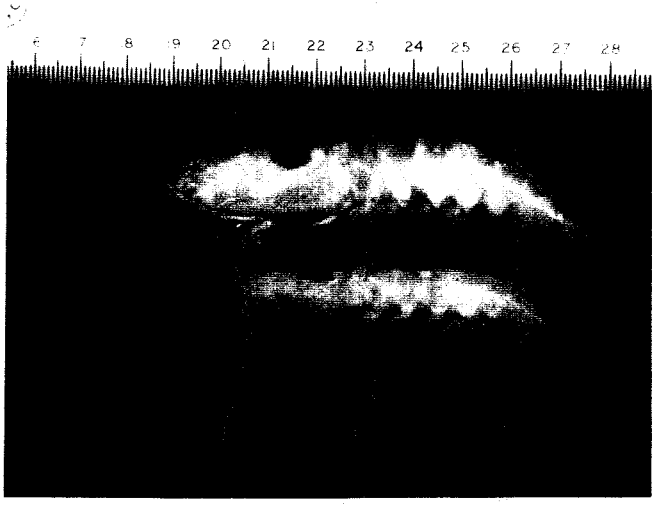

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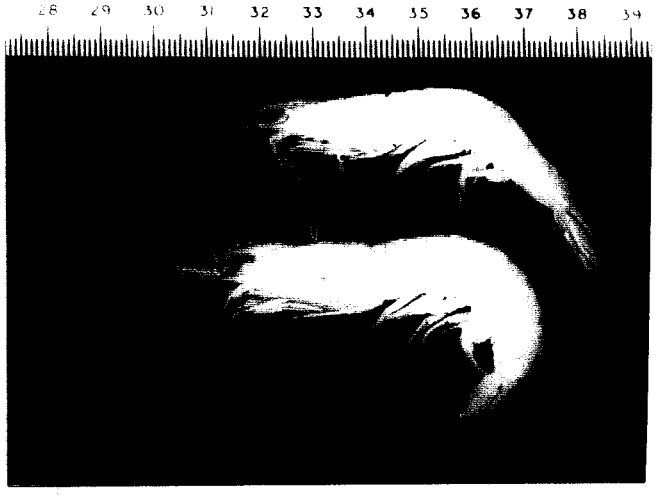
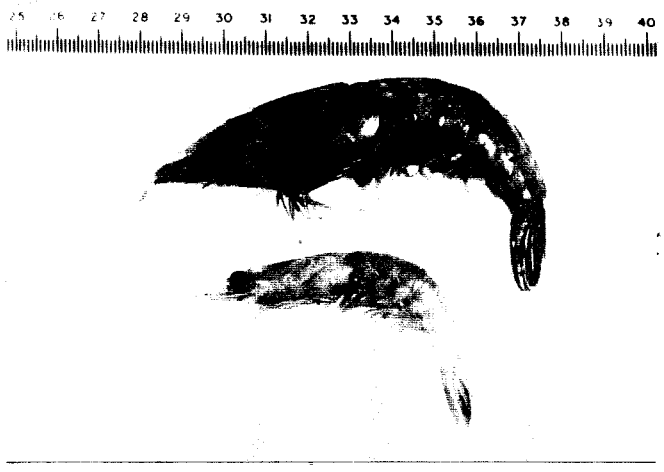


6

PLATE X

1. Paraponeoscopsis maxillipede (Alcock)
2. P. sculptilis (Heller)
3. P. hardwickii (Miers)
4. P. scolivirostris (Alcock)

# PLATE X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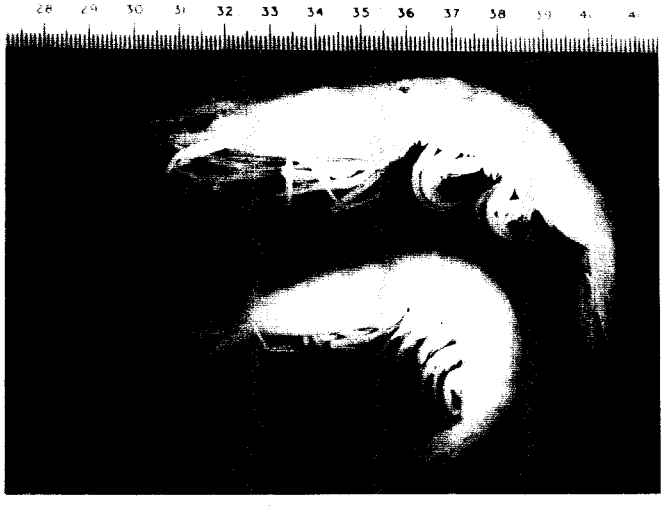
1


27 28 29 30 31 32 33 34 35 36 37 38

2

3


28 29 30 31 32 33 34 35 36 37 38

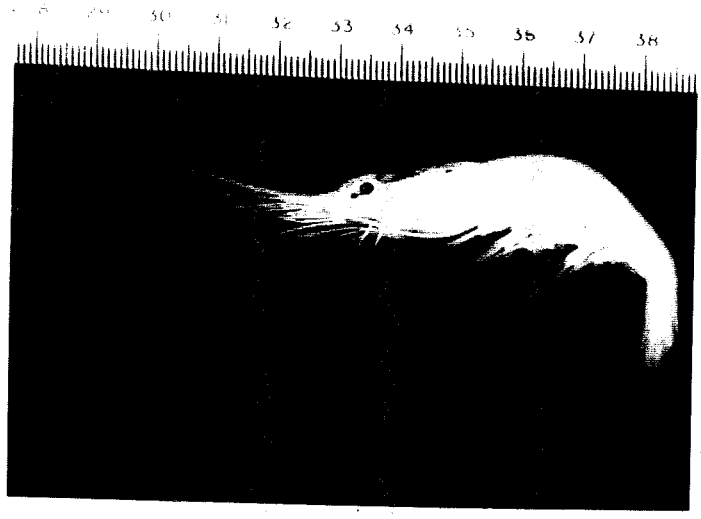
4


34 35 36 37 38 39 40 41

PLATE XI

1. Palaemon tenuipes (Henderson)
2. Macrobrachium rosenbergii (de Man)
3. M. idella (Hilgendorf)
4. M. equidens (Dana)
5. australe (Guerin)
6. acanthurus (Wobili)

# PLATE XI



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2

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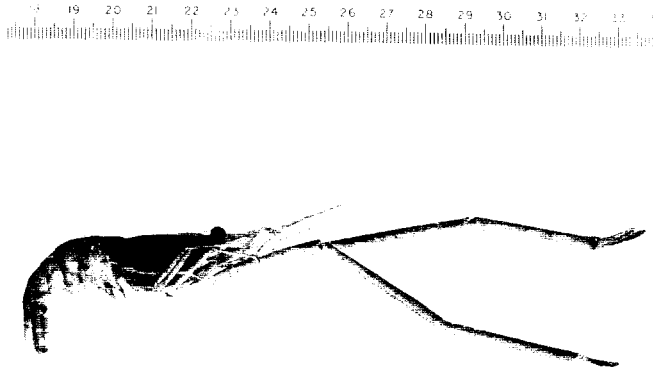

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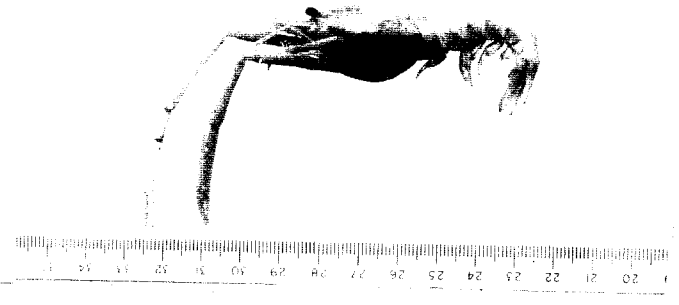

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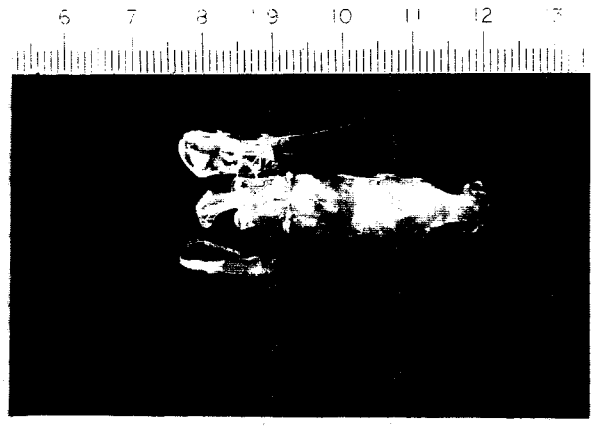
PLATE XII

1. *Hymenocera elegans* Heller
2. *Saron marmoratus* (Olivier)
3. *Athanas dorsalis* (Stimpson)
4. *Alpheus rapax* Fabricius
5. *A. euphrosyne* de Man
6. *A. distinguendus* de Man

PLATE XII

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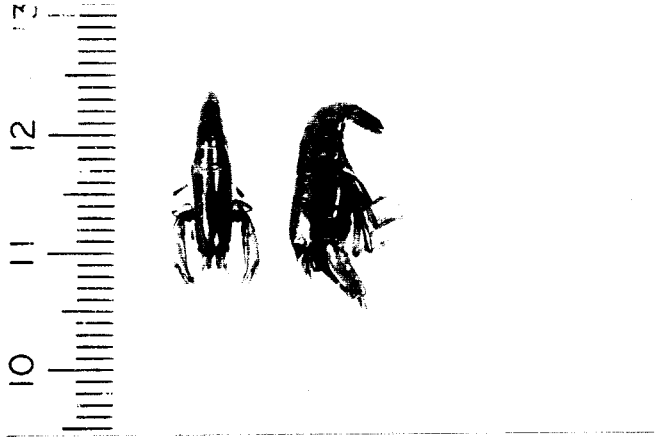


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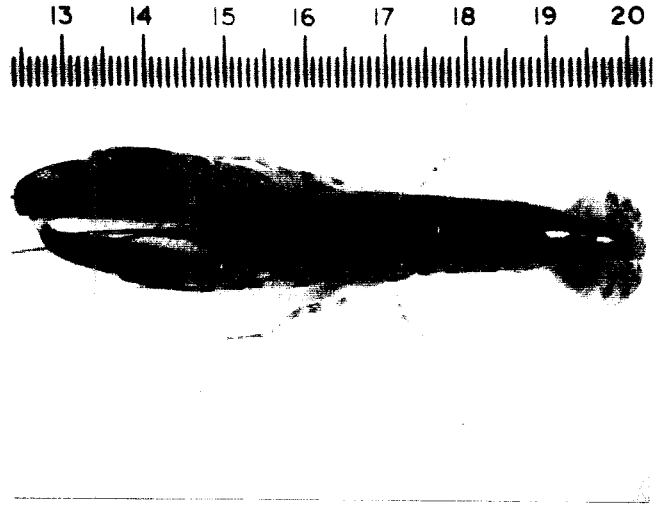


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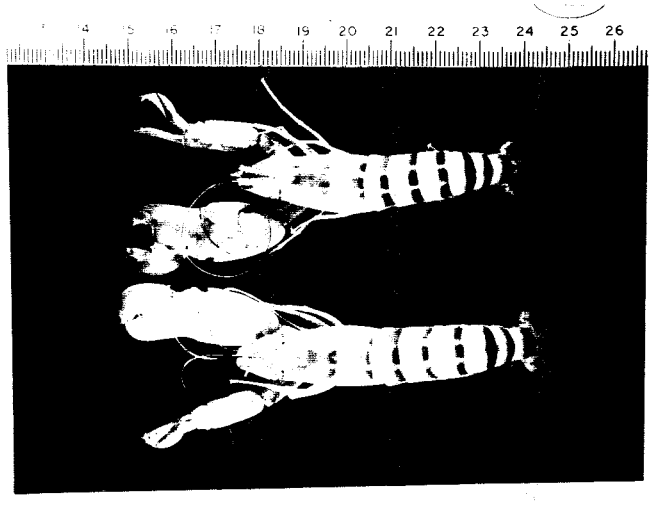


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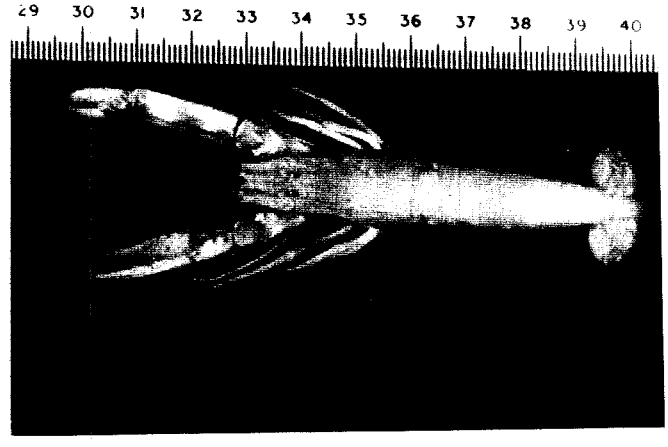



6

## PLATE XIII

1. *Paguropsis typica* Henderson

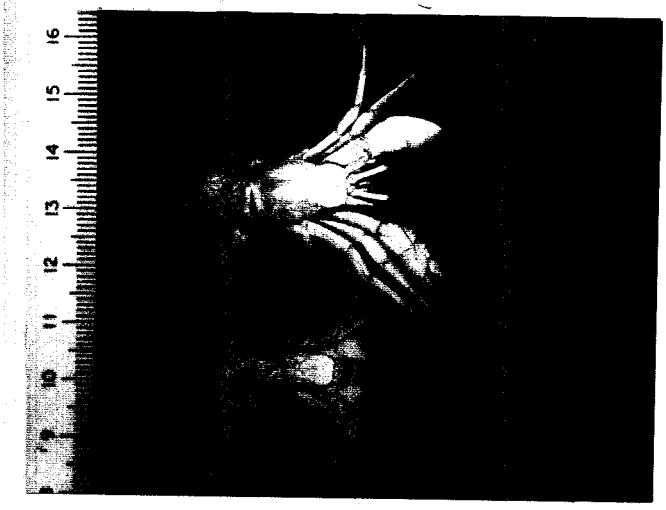
PLATE XIII

I

PLATE XIV

1. *Paucristes longirostris* Dana
2. *Glibanarius infraspinatus* Hilgendorf
3. *Gl. pedavensis* de Man
4. *Gl. longitarsus* (de Haan)
5. *Gl. striolatus* Dana
6. *Gl. glibenarius* (Herbst)

PLATE XIV



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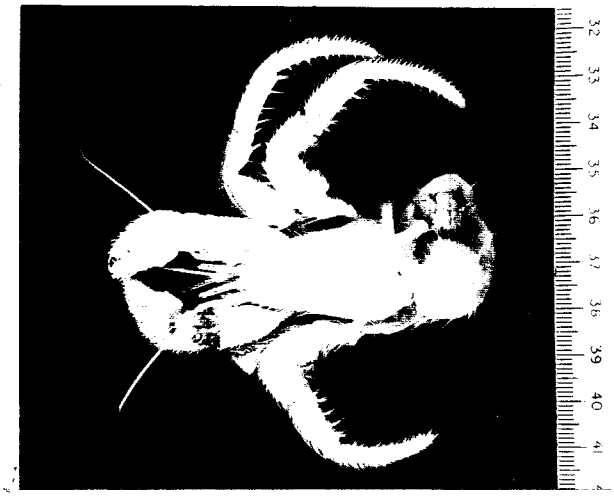

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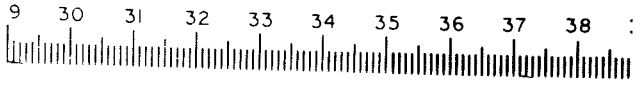


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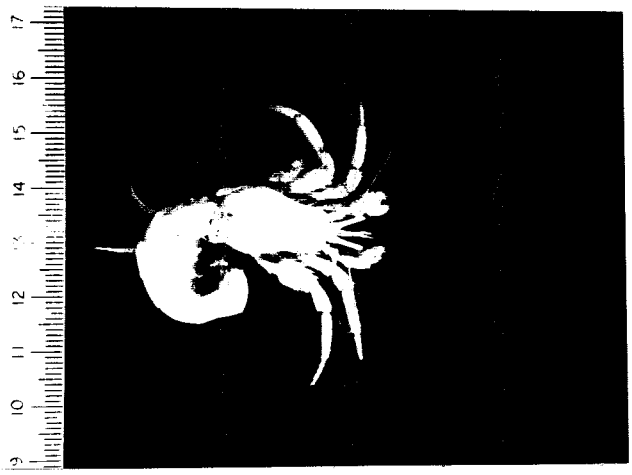
## PLATE XV

1. *Clibanarius erythraeus* de Man
2. *Dardanus setifer* (Milne Edwards)
3. *D. megistos* (Herbst)
4. *D. hessi* (Miers)
5. *D. deformis* (Milne Edwards)

PLATE XV



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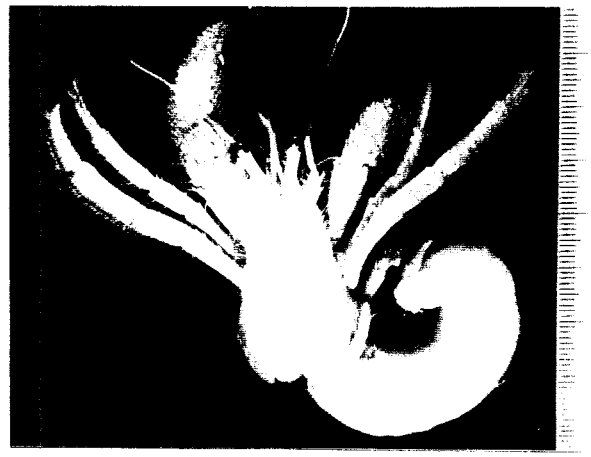

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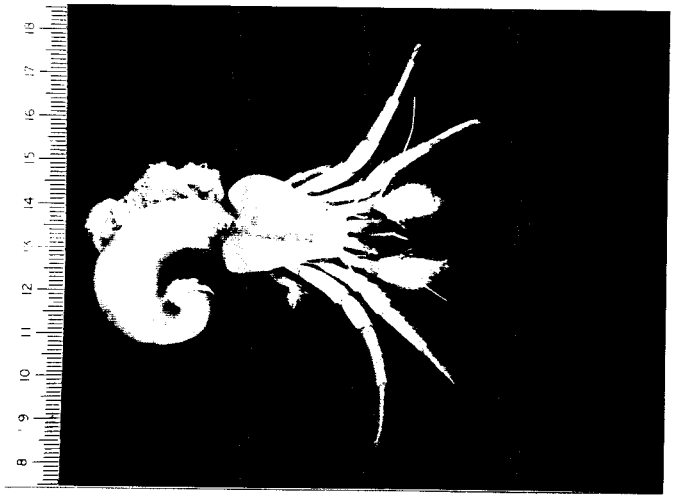

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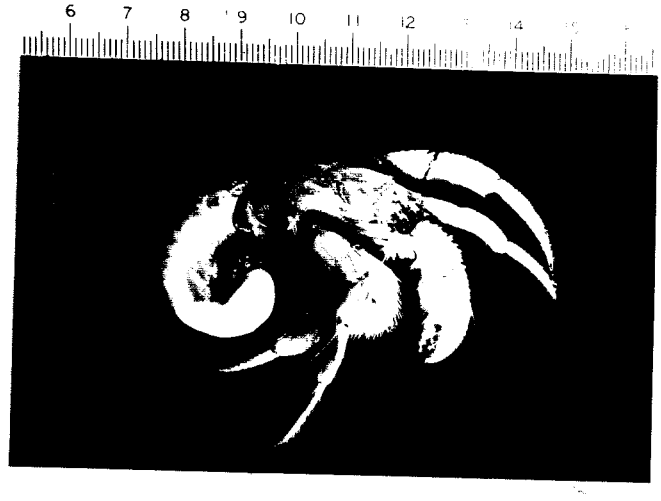
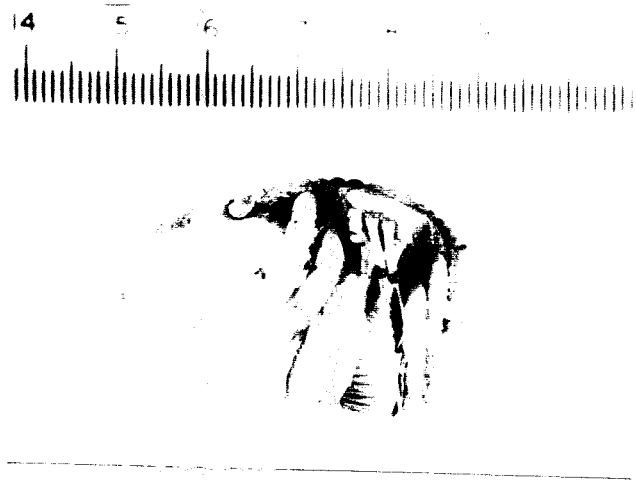


5

## PLATE XVI

1. *Aniculus strigatus* (Herbst)
2. *Diogenes miles* (Herbst)
3. *D. merguiensis* de Man
4. *D. diogenes* (Herbst)
5. *D. custos* (Fabricius)
6. *D. investigatoris* Alcock

PLATE XVI



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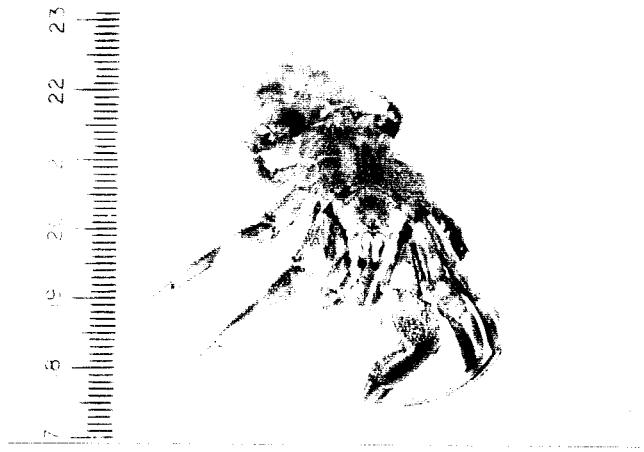

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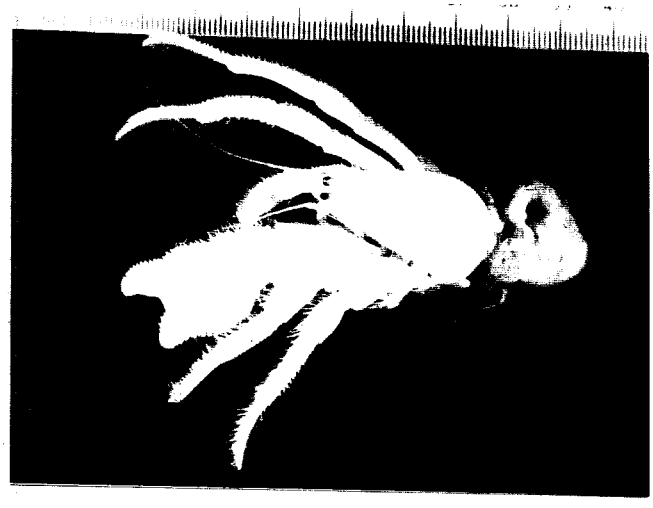

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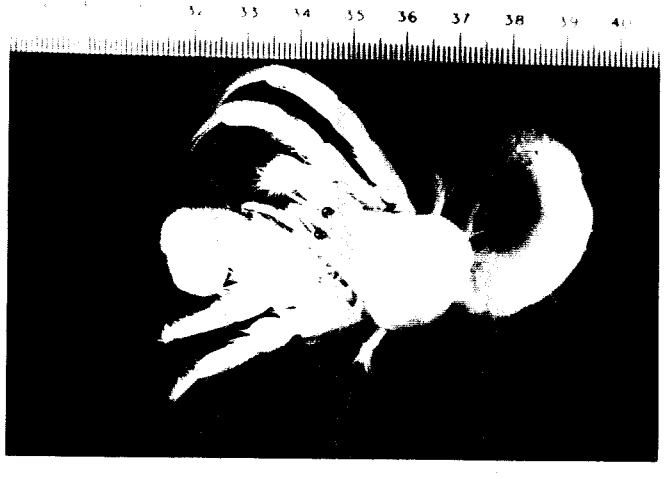

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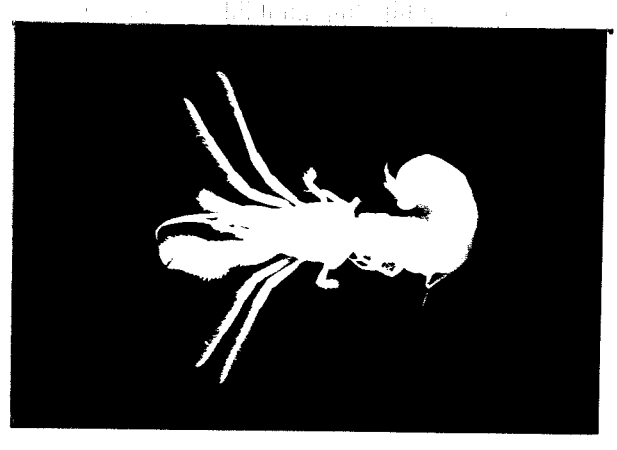
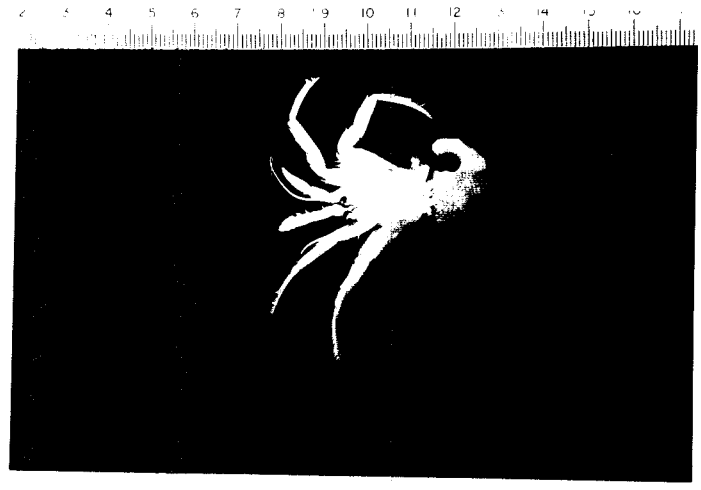


6

PLATE XVII

1. Spiropagurus spiriger (de Haan)
2. Coenobita clypeatus (herbst)
3. C. rugosus (Milne Edwards)

# PLATE XVII



1

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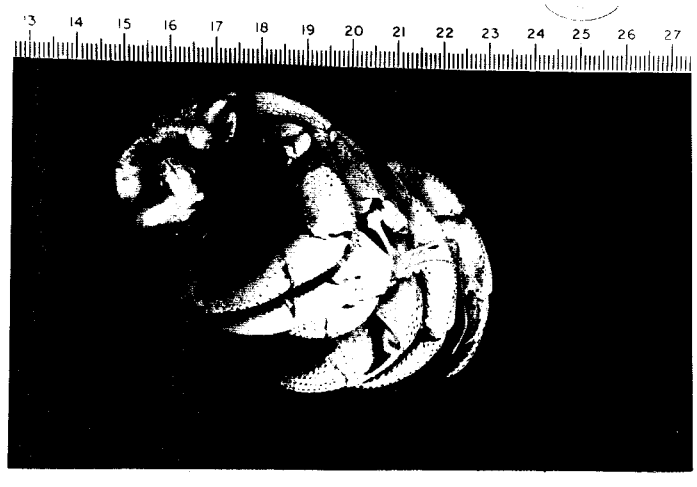


3

## PLATE XVIII

1. Percentage occurrence of important food items in relation to size of *P. semisulcatus* during April to November 1967 from Palk Bay.

2. Percentage occurrence of important food items in relation to size of *P. semisulcatus* during April to November 1968 from Palk Bay.

3. Percentage occurrence of important food items in relation to size of *P. semisulcatus* during November 1968 to February 1969 from Gulf of Mannar.

4. Percentage occurrence of important food items in relation to size of *P. semisulcatus* during November 1967 to February 1968 from Gulf of Mannar.

5. Relationship between fecundity and weight of ovary of *P. semiculcatus*.

6. Relationship between fecundity and carapace length of *P. semiculcatus*.

7. Percentage distribution of mature *P. semisulcatus* in the various size groups during the years 1967-68 and 1968-69 and the average for the two years combined.

# PLATE XVIII

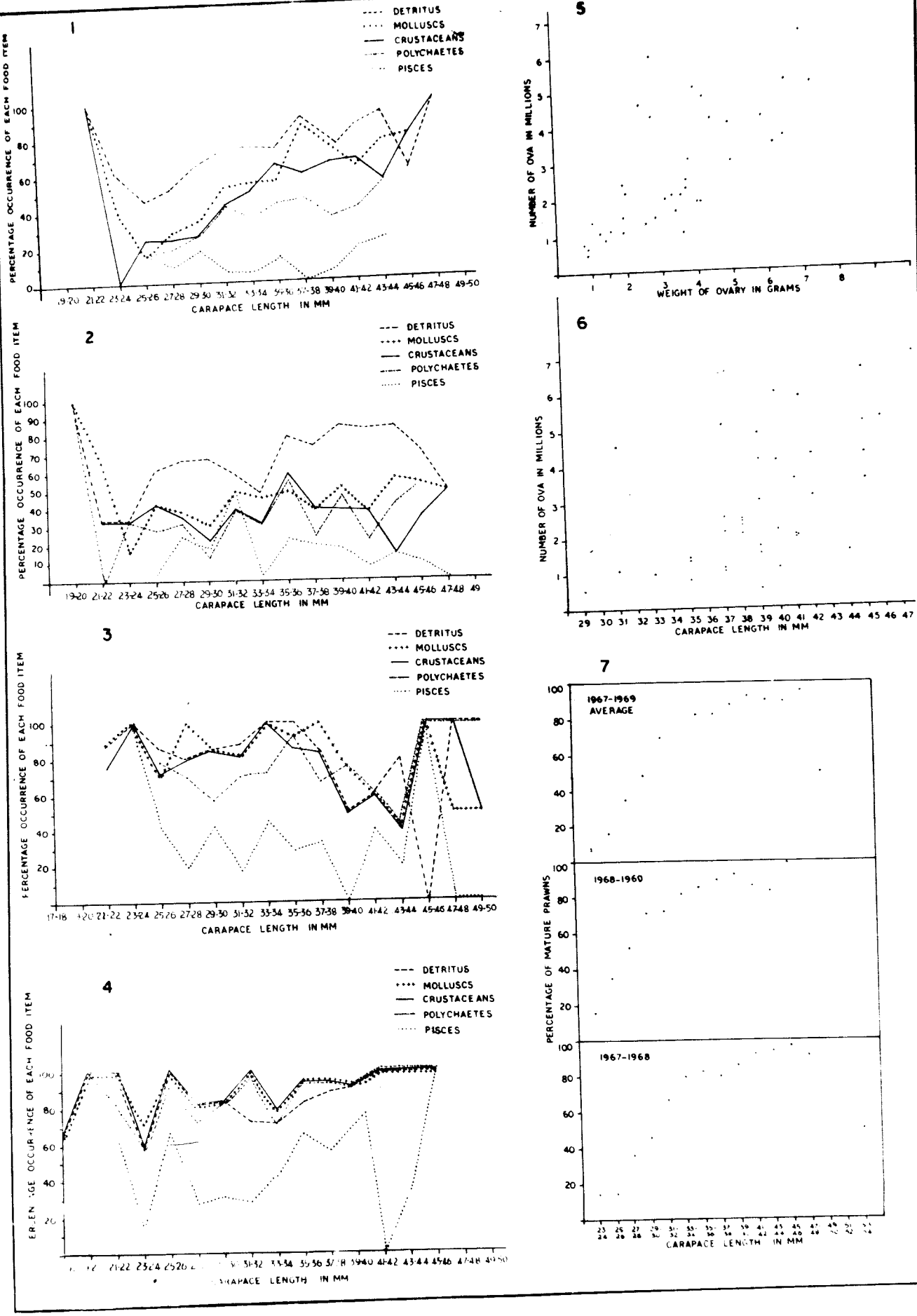
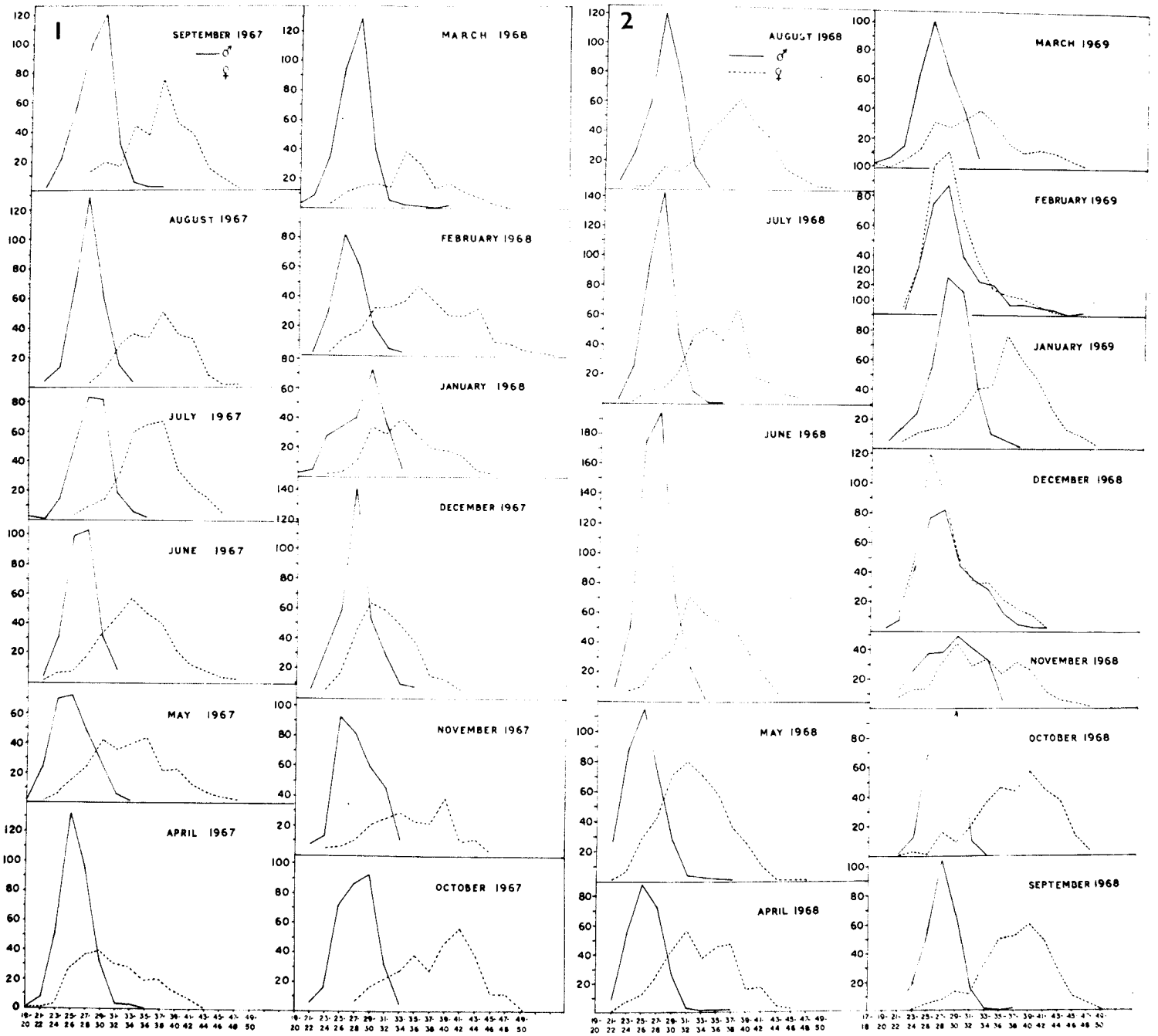

1
DETRITUS
MOLLUSCS
CRUSTACEANS
POLYCHAETES
PISCES
PERCENTAGE OCCURRENCE OF EACH FOOD ITEM
CARAPACE LENGTH IN MM
2
DETRITUS
MOLLUSCS
CRUSTACEANS
POLYCHAETES
PISCES
PERCENTAGE OCCURRENCE OF EACH FOOD ITEM
CARAPACE LENGTH IN MM
3
DETRITUS
MOLLUSCS
CRUSTACEANS
POLYCHAETES
PISCES
PERCENTAGE OCCURRENCE OF EACH FOOD ITEM
CARAPACE LENGTH IN MM
4
DETRITUS
MOLLUSCS
CRUSTACEANS
POLYCHAETES
PISCES
CARAPACE LENGTH IN MM
5
NUMBER OF OVA IN MILLIONS
WEIGHT OF OVARY IN GRAMS
6
NUMBER OF OVA IN MILLIONS
CARAPACE LENGTH IN MM
7
1967-1969
AVERAGE
1968-1960
1967-1968
PERCENTAGE OF MATURE PRAWNS
CARAPACE LENGTH IN MM

PLATE XIX

1. Length frequency distribution of P. semisulcatus for the year April 1967 to March 1968.

2. Length frequency distribution of P. semisulcatus for the year April 1968 to March 1969.

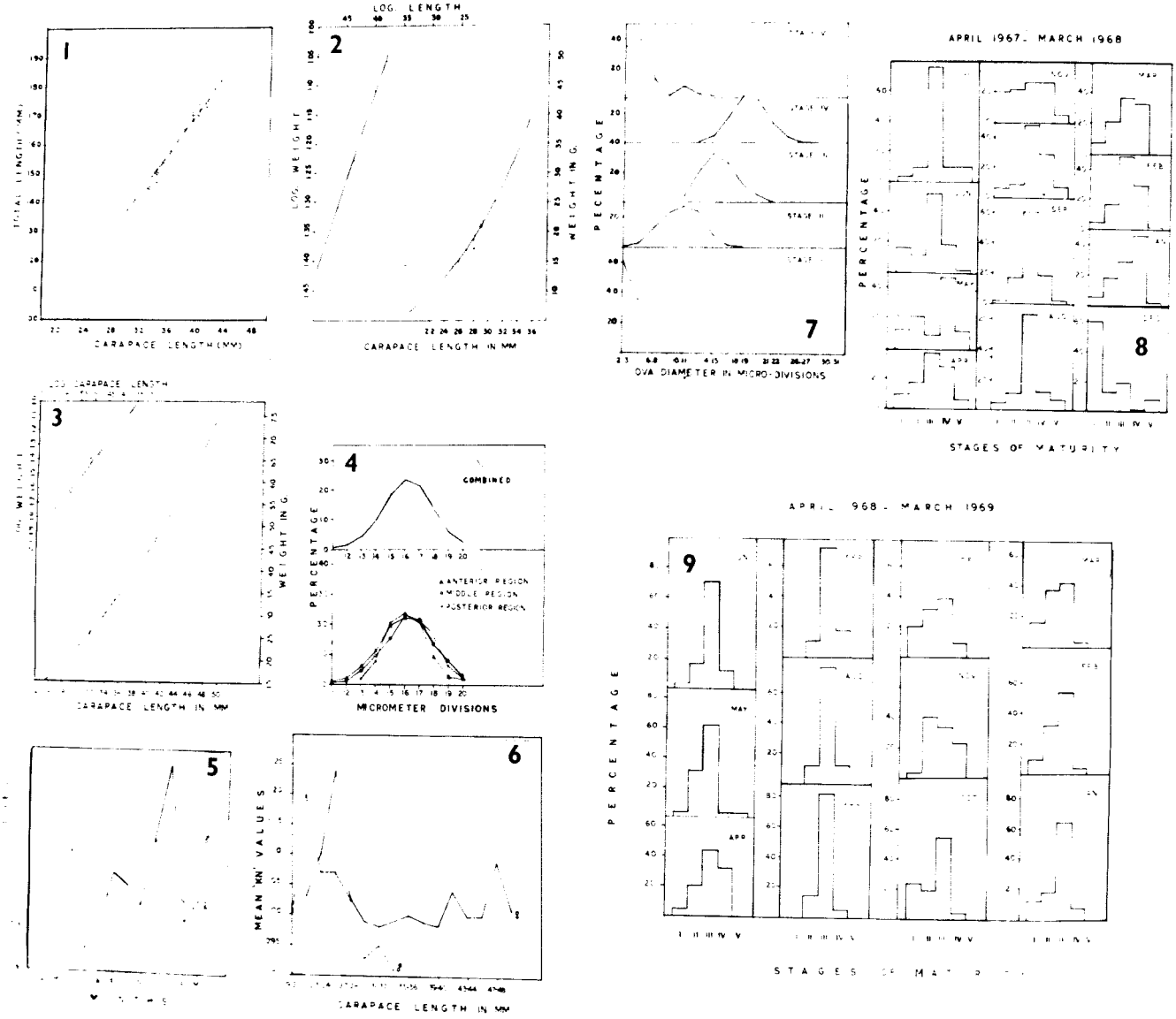
PLATE XIX


1
SEPTEMBER 1967
♂
♀
AUGUST 1967
JULY 1967
JUNE 1967
MAY 1967
APRIL 1967
MARCH 1968
FEBRUARY 1968
JANUARY 1968
DECEMBER 1967
NOVEMBER 1967
OCTOBER 1967
2
AUGUST 1968
JULY 1968
JUNE 1968
MAY 1968
APRIL 1968
MARCH 1969
FEBRUARY 1969
JANUARY 1969
DECEMBER 1968
NOVEMBER 1968
OCTOBER 1968
SEPTEMBER 1968

## PLATE XX

1. Relationship between carapace length and total length of *P. semisulcatus*.
2. Relationship between observed and logarithmic values of length and weight of *P. semisulcatus* - Males.
3. Relationship between observed and logarithmic values of length and weight of *P. semisulcatus* - Females.
4. Comparison of ova diameters from different regions of the ovary of *P. semisulcatus*.
5. Monthly fluctuationsin the mean 'Kn' values of *P. semisulcatus*.
6. Mean 'Kn' values of *P. semisulcatus* at different size groups.
7. Ova diameter frequency polygons of *P. semisulcatus* for stages I - V.
8. Percentage occurrence of gonads in different stages of maturity of *P. semisulcatus* during April 1967 to March 1968.
9. Percentage occurrence of gonads in different stages of maturity of *P. semisulcatus* during April 1968 to March 1969.

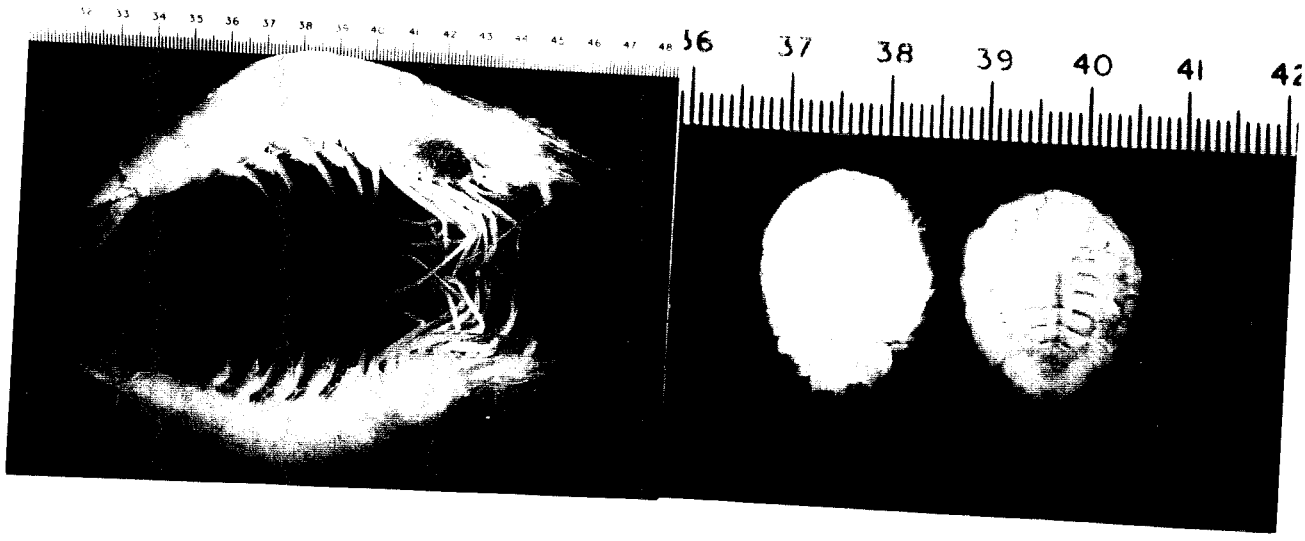
# PLATE XX


1
CARAPACE LENGTH (MM)
2
LOG LENGTH
LOG WEIGHT
WEIGHT IN G.
CARAPACE LENGTH IN MM
7
PERCENTAGE
OVA DIAMETER IN MICRO-DIVISIONS
STAGE IV
STAGE III
STAGE II
APRIL 1967 - MARCH 1968
8
PERCENTAGE
STAGES OF MATURITY
3
LOG CARAPACE LENGTH
LOG WEIGHT
WEIGHT IN G.
CARAPACE LENGTH IN MM
4
COMBINED
PERCENTAGE
ANTERIOR REGION
MIDDLE REGION
POSTERIOR REGION
MICROMETER DIVISIONS
APRIL 968 - MARCH 1969
9
PERCENTAGE
STAGES OF MATURITY
5
6
MEAN 'KN' VALUES
CARAPACE LENGTH IN MM

## PLATE XXI

1. *Penaeus semisulcatus* infected by *Epipenaeon ingens* Nobili
2. *Epipenaeon ingens* Nobili female with male on the ventral surface of abdomen.
3. Microphotograph of *Thelohania* sp. showing spores and pansporoblasts
4. *Thelohania* sp. spores and pansporoblasts magnified.

# PLATE XXI

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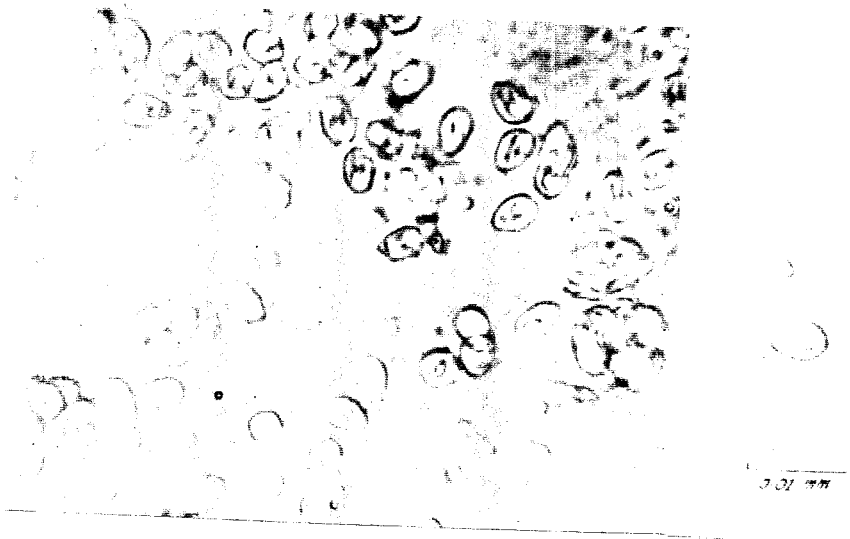

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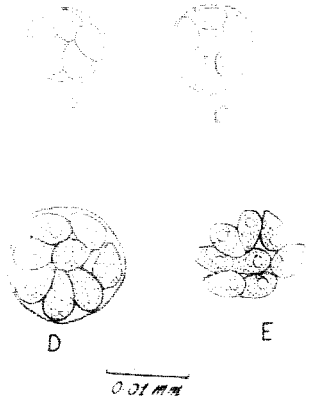
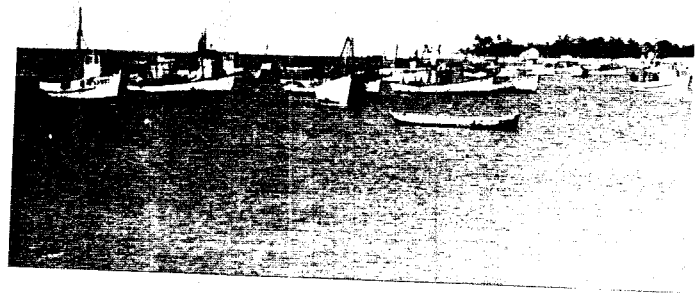



4

## PLATE XXII

1. Mandapam landing centre (Gulf of Mannar)
2. Sorting of prawns.
3. Prawn catch of a mechanised boat.

PLATE XXII



1

2

3

# APPENDIX

*J. Mar. biol. Ass. India*, 1968, **10** (1)

# ON A NEW DISTRIBUTIONAL RECORD OF *PARAPENAEOPSIS TENELLA* (BATE) FROM THE SOUTH-EASTERN COAST OF INDIA

*Parapenaeopsis tenella* (Bate) has been recorded from Japan (Bate, 1888 ; Kishinouye, 1900) ; China (Liu, 1955) ; and Australia (Dall, 1957) in the Pacific Ocean. In 1961 Hall reported it from Malaysia. De Bruin's (1965) record of this species from the east coast of Ceylon extended the distribution of this species further west. Racek and Dall (1965) considered the Palk Strait as the zoogeographical barrier limiting the distribution of the species from the west coast of India where its congener *Parapenaeopsis acclivirostris* (Alcock) occurs. But the present collection of *Parapenaeopsis tenella* from Palk Bay and Gulf of Mannar has established its presence beyond the Palk Strait which obviously does not act as a barrier. The discontinuous distributional records are probably due to the small size of the specimen and hence the rarity in the commercial catches.

Male and female specimens of *Parapenaeopsis tenella* were collected from the early morning landings on the Gulf of Mannar side of Mandapam Camp and the Palk Bay side of Rameswaram Island. The specimens were obtained only from the night catches of shore seines as well as boat seines from depths of 1-2 fathoms and 5-6 fathoms respectively.

**Parapenaeopsis tenella** (Bate, 1888)

*Penaeus tenellus* Bate, 1888, pp. 270-71 ; Kishinouye, 1900, p. 22.

*Parapenaeopsis tenellus* Kubo, 1949, pp. 371-74 ; Liu, 1955, pp. 16-17 ; Dall, 1957, pp. 221-23.

*Parapenaeopsis tenella* Hall, 1961, p. 89 ; Hall, 1962, p. 26 ; de Bruin, 1965, pp. 98-99 ; Racek and Dall, 1965, pp. 108-109.

*Material :* 6 ♂♂, 24-33 mm ; 5 ♀♀, 29-43 mm ; Mandapam Camp (Gulf of Mannar) and 69 ♂♂, 24-32 mm ; 17 ♀♀, 29-44 mm ; off Thangachimadam (Palk Bay). Depth of occurrence 1-6 fathoms.

*Distribution :* Southern Japan to northern Australia, northern China through Malaysia to Ceylon and south-eastern coast of India.

*Discussion :* This well-described species closely resembling *Parapenaeopsis aclivirostris* (Alcock) could be easily distinguished from it by the presence of the wing-like lateral expansions of the petasma. The appendix masculina has a broad distal piece and bears minute setae. The characteristic tongue-like process and the excavation on the posterio-distal portion are well marked. The thelycum has an anterior plate one-and-a-half times as wide as long with a posteriorly directed tongue-like process enclosed in a shallow depression of the flat anterior thelycal plate. The post-ocular sulcus is distinct, but shallow. Although the Indian specimens agree with Dall's (1957) description in most of the morphological characters, there are certain differences. Unlike the Australian specimens the rostrum does not reach the

tip of the second antennular segment in Indian forms. Post-rostral carina which is indistinct posteriorly, ends at $\frac{1}{3}$ carapace. The stylocerite reaches $\frac{1}{3}$ basal segment of the antennular peduncle. First pereiopod exceeds the pterygostomial angle by the length of the propodus.

The Indian forms are more similar to the Australian forms than the Ceylonese particularly in the following characters :

1. In Indian and Australian forms the rostrum reaches almost to the tip of the second segment of the antennular peduncle while in Ceylonese forms it extends to or exceeds the tip of the third segment of the antennular peduncle.

2. Adrostral carina in Australian and Indian forms ends at $\frac{1}{4}$ the distance from the anterior border of the carapace. But in Ceylonese forms it ends at $\frac{1}{10}$th distance from the anterior border of carapace.

3. Fourth pereiopod of Indian and Australian forms extends to the tip of the first segment of the antennular peduncle whereas in Ceylonese forms it reaches upto the middle of the second segment.

The fifth pereiopod reaches the tip of the second segment of antennular peduncle in Australian forms whereas in Indian forms it reaches upto the middle only. In Ceylonese specimens it exceeds the third segment of antennular peduncle (in females). There are 10-12 minute, pointed, forwardly directed spines on the hepatic carina visible under low magnification. Besides, 4-5 similar spines are situated in the anterior portion of the hepatic sulcus. The hepatic spine has an accessory spine at its base on the ventral side and two on the dorsal side. These spines, however, have not been mentioned by any of the previous workers. Ground colour of body is creamy white with red, black and dark brown chromatophores distributed in a definite pattern along the sides of the rostrum, bases of the ophthalmic peduncles, sides of the carapace, posterior margin of the abdominal segments and margins and tips of telson and uropods on freshly preserved specimens.

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# Notes on some interesting penaeid prawns (Crustacea, Decapoda) from the southeast coast of India

BY

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DURING routine collection of prawn samples of commercial catches from certain localities in Palk Bay and Gulf of Mannar on the southeast coast of India specimens of *Penaeus latisulcatus* Kishinouye, *Trachypenaeus pescadoreensis* Schmitt, *Trachypenaeus sedili* Hall and *Parapenaeopsis uncta* Alcock were collected. The occurrence of these prawns is reported for the first time from this area.

## **Penaeus latisulcatus** Kishinouye, 1900

*Penaeus latisulcatus* Kishinouye, 1900, p. 12. de Man, 1911, pp. 108-111. Kubo, 1949, pp. 278-282. Racek, 1955, pp. 222-223 ; 1959, pp. 10-11. Hall, 1956, p. 72 ; 1962, pp. 14-15. Dall, 1957, pp. 149-151. Cheung, 1960, p. 64. Joubert, 1965, pp. 17-18. Racek and Dall, 1965, pp. 12-13. de Bruin, 1965, pp. 74-75. Mohamed 1969, p. 29. George, 1969, p. 22.

*Peneus latisulcatus* Schmitt, 1926, pp. 365-367.

*Penaeus canaliculatus* Oliv. var ? Lanchester, 1901, p. 571.

*Penaeus canaliculatus* var. *australiensis* de Man, 1902, p. 905.

*Material :* 17 specimens. Rameswaram (Palk Bay) : 1 male, carapace length 29 mm and 2 females, 27 and 30 mm ; Vedalai (Gulf of Mannar) : 9 males, 17-26 mm and 1 female, 15 mm; Pudumadam (Gulf of Mannar) : 1 male, 33 mm and 3 females, 38-45 mm. Depth 1-12 m. Collected from the night catches of trawl nets.

*Discussion :* The specimens agree with the description given by Dall (1957) and others. The bifid processes of the anterior plate of the thelycum are stumpy in young ones (Fig. I, A) while long and slender, their tips turning inwards, in adults (Fig. I, B). On the contrary, according to de Man (1911) the adult female specimen from Japan had short anterior processes of the thelycum while the young female from Djeddah, Red Sea, measuring 110 mm in total length (de Man, 1888) had comparatively long, slender and tapering anterior process, distally curved inwards. He suggested that the differences between these processes of female specimens from the above two localities may be due to the difference in age. The young specimens from the Gulf of Mannar and Palk Bay were compared with similar specimens

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collected from Androth and Minicoy Islands in the Laccadive Archipelago and they were also found to possess short, horn-like processes of the thelycum.

The colouration in life is the same as described by Dall. The prosartema also is brown coloured.

*Distribution :* Djeddah (Red Sea), Pudumadam, Vedalai (Gulf of Mannar), Rameswaram (Palk Bay), Malaysia, Molluccas to Korea, Japan and Australia.

**Trachypenaeus pescadoreensis** Schmitt, 1931

*Trachypeneus pescadoreensis* Schmitt, 1931, pp. 265-268. Hall, 1962, p. 29. Cheung, 1960, p. 65 (Key only).

*Trachypenaeus pescadoreensis* Mohamed, 1969, p. 30. George, 1969, p. 33.

*Trachypeneus granulosus* Hall, 1961, p. 100.

*Trachypeneus furcilla* Hall, 1961, pp. 102-104.

*Material :* 35 specimens. Rameswaram (Palk Bay) : 4 females, carapace length 20-22 mm ; Thangachimadam (Palk Bay) : 6 males, 11-13 mm and 7 females, 11-16 mm ; Vedalai (Gulf of Mannar) : 6 males, 10-12 mm and 3 females, 12-13 mm ; Mandapam (Gulf of Mannar): 1 male, 12 mm and 8 females, 16-21 mm. Depth 2-12 m. Collected from trawl net, boat seine and shore seine catches. of night fishing operations.

*Discussion :* The cardiac plate has 35-42 spinules (Fig. I, C). Zyzocardiac ossicle with principal tooth and an upper and lower row of 10-15 teeth, each row ending in a cluster of smaller teeth. Prepyloric with a median blunt tooth and a row of fifteen teeth on either side. The distal piece of the appendix masculina is broader anteriorly and fringed with spinules on the distal and distolateral aspects. It has half the length of the proximal piece.

*Trachypenaeus pescadoreensis* Schmitt is closely related to *Trachypenaeus granulosus* (Haswall), though it differs from the above species in the structure of the thelycum and petasma. Unlike that of *T. granulosus* the anterior thelycal plate in *T. pescadoreensis* does not reach the posterior margin of the posterior plate. The petasma has a conspicuous wing-like expansion on the outer side of the distolateral projections. Besides, the appendix masculina in this species has a series of spinules on the distal and distolateral aspects of the distal piece whereas in *T. granulosus* from Australia (Dall, 1957) the spinules are only present at the distal end.

*Distribution :* Vedalai, Mandapam (Gulf of Mannar), Rameswaram, Thangachimadam (Palk Bay), Malaysia and Formosa.

**Trachypenaeus sedili** Hall, 1961

*Trachypeneus sedili* Hall, 1961, pp. 100-102 ; 1962, p. 30. de Bruin, 1965, pp. 92-93.

*Trachypenaeus sedili* Racek and Dall, 1965, p. 92. Mohamed, 1969, p. 30. George, 1969, p. 33.

*Material :* 22 specimens. Rameswaram (Palk Bay): 3 males, carapace length 8.5-9.5 mm and 7 females, 11.5-14.5 mm ; Mandapam (Gulf of Mannar) : 3 males, 10.5-11.0 mm and 9 females, 11.0-19.0 mm. Depth 2-25 m. Collected from the trawl catches from muddy bottom during night.

*Discussion :* De Bruin (1965) has recorded the male of *T. sedili* from Ceylon. Since he has not given the description the male is described here, for the first time.

*Allotype :* Male.

The rostrum is straight with epigastric tooth and eight teeth on the upper surface. It reaches a little beyond the base of the second segment of the antennular peduncle. The epigastric tooth is placed a short distance behind the hepatic spine. The first rostral tooth is situated above the supraorbital margin. The post-orbital carina extends to about two-thirds the distance towards the posterior margin of the carapace. The adrostral sulcus ends a little short of the first dorsal tooth. The carapace and abdomen are heavily setose. The postorbital spine is small but well defined while the antennal spine is large. The hepatic spine is rather small. The carina of the carapace are not well defined. The antennal sulcus is only discernible while the cervical sulcus is wide and shallow. The hepatic sulcus extends back to the middle of the carapace and anteriorly curves obliquely down towards the pterygostomian angle, becoming broader and less defined.

The first abdominal segment is not carinated, dorsally. The second segment has a small elevation, dorsally, just behind the anterior margin and the third to sixth segments are carinated, the carina of the sixth segment ending in a spine. The postero-ventral angles of the sixth segment are produced into spines. The length of the sixth segment is a little more or equal to the depth.

Telson is slightly longer than the sixth segment, exceeding the uropod by its distal spine. The dorsal sulcus of the telson is deep and provided with straight and hook-like spinules. The marginal spines are larger and movable, the last being placed proximal to the base of the terminal spine.

The basal segment of the ocular peduncle has a spine on the dorsal side. The prosartema falls short of the anterior margin of the cornea. The stylocerite is nearly half the length of the cornea. The length of the cornea is about one-third the length of the carapace. The second antennular segment is almost twice as long as the third segment while the antennular flagella are nearly as long as the antennular peduncle. The scaphocerite reaches the base of the third antennular segment, the lateral spine surpassing the joint.

The third maxilliped exceeds the carpocerite by the dactylus and one-fourth of the propodus. The first leg reaches a little beyond the middle of the carpocerite and bears a long, curved basial spine. The second leg also bears a similar basial spine and reaches the middle of the scaphocerite. The third and fourth legs reach a little short of the tip of the scaphocerite and one-third length of the scaphocerite respectively and do not bear spines. The fifth leg falls a little short of the tip of the scaphocerite. The first three legs bear mastigobranchs.

Cardiac plate has 32 spinules (Fig. I, J. ). The zyzocardiac ossicle has two principal teeth and two rows of 9 to 10 teeth.

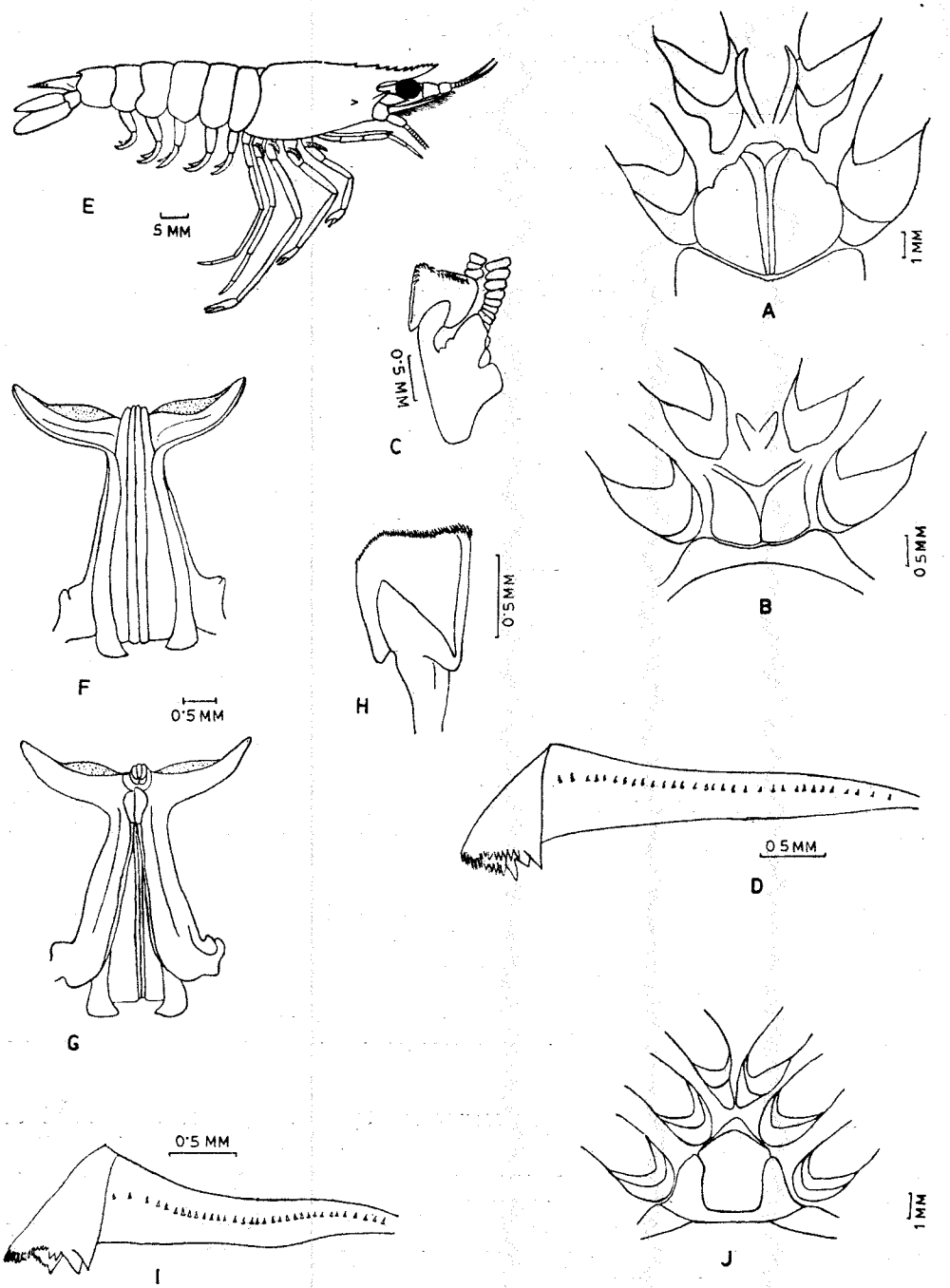


FIGURE I. A and B, *Penaeus latisulcatus* Kishinouye ; A, thelycum of young female ; B, thelycum of adult female ; C and D, *Trachypenaeus pescadoreensis* Schmitt ; C, appendix masculina ; D, cardiac plate and zyzocardiac ossicle ; E-K, *Trachypenaeus sedili* Hall ; E, male, lateral view ; F, petasma, dorsal view ; G, same, ventral view ; H, appendix masculina, left side, dorsal view ; I, same, distal piece, ventral view ; J, cardiac plate and zyzocardiac ossicle ; K, thelycum.

The petasma (Fig. I, E & F) reaches the bases of the third pair of pereiopods. Its greatest width across the distolateral projections is equal to its length. The distolateral projections taper distally and curve slightly forwards. The distomedian projections curve ventrally enclosing the distal opening of the petasma.

Appendix masculina (Fig. I, H & I) has a distal piece bearing spinules on its tip and the inner side. The basal piece is more than double the length of the distal piece.

The female specimens agree well with the description given by Hall (1961). The chair-like nature of the thelycum is well defined in the present material (Fig. I, K ). However, the figure given by de Bruin (1965) is quite different from this.

The general body colour in live specimen is yellowish white with dark yellow patches. The posterior margin of the carapace is brown. The rostrum also is brown, becoming lighter towards the tip. Antennae are white while the flagella are yellowish pink. Pereiopods are tipped white. Pleopods with light green iridiscent patches on the bases and exopods on the external aspect. Uropods are dark brown middle and margins becoming whitish towards their tips. Telson distally brown and with yellowish setae.

*Distribution :* Mandapam (Gulf of Mannar), Rameswaram (Palk Bay), Malaysia and Singapore.

**Parapenaeopsis uncta** Alcock, 1905

*Parapeneopsis uncta* Alcock, 1905, p. 528 ; 1906, p. 39. de Bruin, 1965, pp. 96-98.

*Parapenaeopsis uncta* Menon, 1956, p. 346. Mohamed, 1969, p. 30. George, 1969, p. 34.

*Parapeneopsis probata* Hall, 1961, pp. 96-98 ; 1962, p. 27.

*Material :* 44 specimens. Off Pudumadam (Gulf of Mannar) : 8 males, carapace length 18-22 mm and 34 females, 16-39 mm; Kilakkarai (Gulf of Mannar) : 1 male, 18 mm and 1 female, 24 mm. Depth 5-20 m. Collected from trawl catches of night fishing.

*Discussion*

*Parapenaeopsis uncta* Alcock collected from Gulf of Mannar is in close agreement with the description given by Alcock (1906) in most of the characters excepting the following.

The rostrum is distinctly sigmoid in all the adult females. In young males the rostrum has an upturned, short and pointed tip beyond the toothed portion. In adult males, however, the rostral tip is straight as in the case of the specimens from Ceylon (de Bruin, 1965). Only in two specimens, out of the total of nine males examined, the tips of the rostrum were pointed and upturned. In fifty per cent of the female specimens examined from the Gulf of Mannar, the rostrum reached the tip of the third antennular segment while in the rest it extended upto the middle of this segment. In most of the females from Madras (Bay of Bengal) the rostrum surpassed the antennular peduncle by one and a half the length of the third antennular segment.

In all females, except one, the telson was longer than the sixth abdominal segment, while in one it was equal in length. In males, only two had telson longer than the sixth segment while it was equal in others. The telson reached the tip of the inner caudal swimmeret in all specimens. Third maxilliped reached nearly the middle of the antennal scale, surpassing the tip of the fifth leg by the length of dactylus and half the propodus.

Hall (1961) described *Parapeneopsis probata* as a new species. De Bruin (1965) has correctly pointed out the intraspecific nature of these characters separating this species and *P. uncta* and synonymised the two. In fact, the shape of the rostrum, the proportions of the rostrum and antennular peduncle, the telson and the sixth abdominal segment, the nature of the antero-inferior angle of the carapace and the extent of development of the spine on the second pereiopod are so identical in specimens from Singapore, India and Ceylon that the syonymy of the two species cannot be doubted.

There is no detailed record of the colour of this species except the mention of the reddish area near the posterior border of the carapace by Hall (1961). The ground colour of the fresh specimen is pale yellow. Besides the above mentioned reddish patch on the carapace, the anterior one-third of the carapace is darker in shade. The rostral teeth are tipped yellow. Abdomen has a brown band across the posterior half of each segment. Appendages are pale yellow with bright yellowish tips. Antennular peduncles are dark with pale yellow flagella. Antennal scale bordered dark brown while the flagella are yellowish with dark cross bands. Uropods are yellow with dark brown patches near the extremities and bases.

The largest female collected from the Gulf of Mannar measured 39 mm in carapace length which is much larger than recorded by Hall from Singapore and probably by de Bruin from Ceylon, the same measurements being mentioned as both carapace length and total length at different places by him.

*Distribution :* Kilakkarai, Pudumadam (Gulf of Mannar), Ceylon, Madras, and Ganjam (Bay of Bengal) and Singapore.

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* Not referred to in the original

# *METAPENAEOPSIS BORRADAILI* (DE MAN) A PENAEID PRAWN (DECAPODA, PENAEIDAE) NEW TO THE INDIAN OCEAN

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## INTRODUCTION

*METAPENAEOPSIS BORRADAILI* (de Man) has been described from the type localities of Siboga Expedition, by de Man (1911) and later from Australia by obtaining a single male by Dall (1957). The present material from the Laccadive Archipelago was kindly passed on to me for study by Dr. S. Jones, former Director of Central Marine Fisheries Research Institute. The specimens were collected from the coral reef area and the lagoons of the Islands during the collection of fishes using fish poison. This is the first report of the species from the Indian Ocean, thus extending its distribution far west to the Arabian Sea.

**Metapenaeopsis borradaili** (de Man)

(Figure 1, A-G)

*Penaeopsis borradailei* de Man, 1911, pp. 73-75, pl. VIII, fig. 24 a, b.

*Metapenaeopsis borradailei* Dall, 1957, pp. 174-76, fig. 13, A-E.

*Metapenaeopsis borradaili* Racek and Dall, 1965, p. 20 (in key).

*Material :* 30 specimens. Minicoy Island : 12 males, total length 23.5-39 mm. ; 7 females, 24-47.6 mm. Coll. 21-7-1967. Chetlat Island : 4 males, 25.4-38.8 mm. ; 2 females, 38-42.2 mm. Coll. 21-7-1967. Kalpeni Island : 1 male, 32.7 mm.Coll. 25-5- 1965. Kavarathy Island : 1 male, 38 mm. ; 3 females, 46-51 mm. Coll. 22-12-1968. All specimens were collected from shallow waters of 1-3 metres depth by Mr. M. Ali Manikfan.

*Distribution :* Karakelang Island, Sanana Bay and Nilahia Bay (Siboga localities) ; Murray Island (Torres Strait) and Laccadive Archipelago (Arabian Sea).

## DESCRIPTION

*Metapenaeopsis borradaili* can be easily distinguished by the distinctive petasma, the possession of distal segment of appendix masculina, the presence of a single median pointed spine between the bases of the fourth pair of coxae and the paired subrectangular plates situated posterior to this spine. Besides, the nature of hepatic sulcus and the absence of dorsal carina on the abdomen anterior to the fifth somite are other characters of taxonomic importance. The present material agrees in general with the description given by Dall (1957) though there are some differences, which are also discussed here.

*Rostrum :* The specimens from the Laccadive Archipelago have straight, upturned rostrum with 9 teeth and the epigastric tooth, reaching only to the middle of the first antennular segment, while in the Australian form it reaches the tip of the second segment of antennular peduncle.

*Carapace :* The antennal carina does not extend beyond the base of the antennal spine.

*Antennule :* The upper flagellum of the antennule is shorter than the lower, 1/3 as long as the peduncle and only less than 1/4 the carapace length unlike that of the Australian forms. The prosartema is 1/2 the long axis of the cornea and is as long as the stylocerite.

*Thoracic legs :* The third pereopod reaches only to the base of the second segment of the antennular peduncle.

*Abdomen :* The fifth and sixth abdominal segments only have the dorsal carina which end posteriorly in a spinule. The sixth segment is 1.5 times as long as wide. The telson is 4 times as long as broad and bear four pairs of lateral spines. The proximal of these is small and placed at half the length of the telson. The second pair which is longer and slender is situated at half the distance from the tip of the telson and the next pair which is the longest is nearly 5 times the length of the most proximal one. The fourth pair of spines are 3/5 the length of the penultimate pair of spines and situated at the base of the terminal spine (Fig. 1, G). Dall's specimen is reported to have only three movable spines on either side of the telson.

*Gastric mill :* The cardiac plate has 22 spinules. The zygocardiac ossicle is provided with five stout teeth, of which three are in the upper and two in the lower rows, followed by a series of slender spinules. The prepyloric ossicle has a large median tooth and a series of 5-6 small teeth on either side (Fig. 1, E, F).

*Petasma :* The structure of the petasma in the males differs from that described from Australia by Dall. The distolateral projections are large, much expanded and overhang dorsally over the apex of the petasma. The left distoventral projections are highly reduced. The distodorsal lobules are well developed. The distomedian lobules are bifid as in Dall's specimen, reaching the base of the third pereopods and bear minute setae at the distal end (Fig. 1, A, B).

*Appendix masculina :* The distal segment of the appendix masculina in *M. borradaili* from Laccadives is 1/4 the basal segment while in the Australian specimen it is only 1/8 in length (Fig. 1, C).

*Thelycum :* The structure of the thelycum agrees well with the Siboga specimens described and figured by de Man (1911). The median processes of the anterior thelycal plate is well developed. The paired posterior plates have a little wider groove in between. The paired processes situated between the bases of the second pair of pereopods are more slender, elongated and separate at the base (Fig. 1, D).

## SUMMARY

*Metapenaeopsis borradaili* (de Man) is reported from the Indian Ocean for the first time. The differences between the present material from the Laccadive Archi-

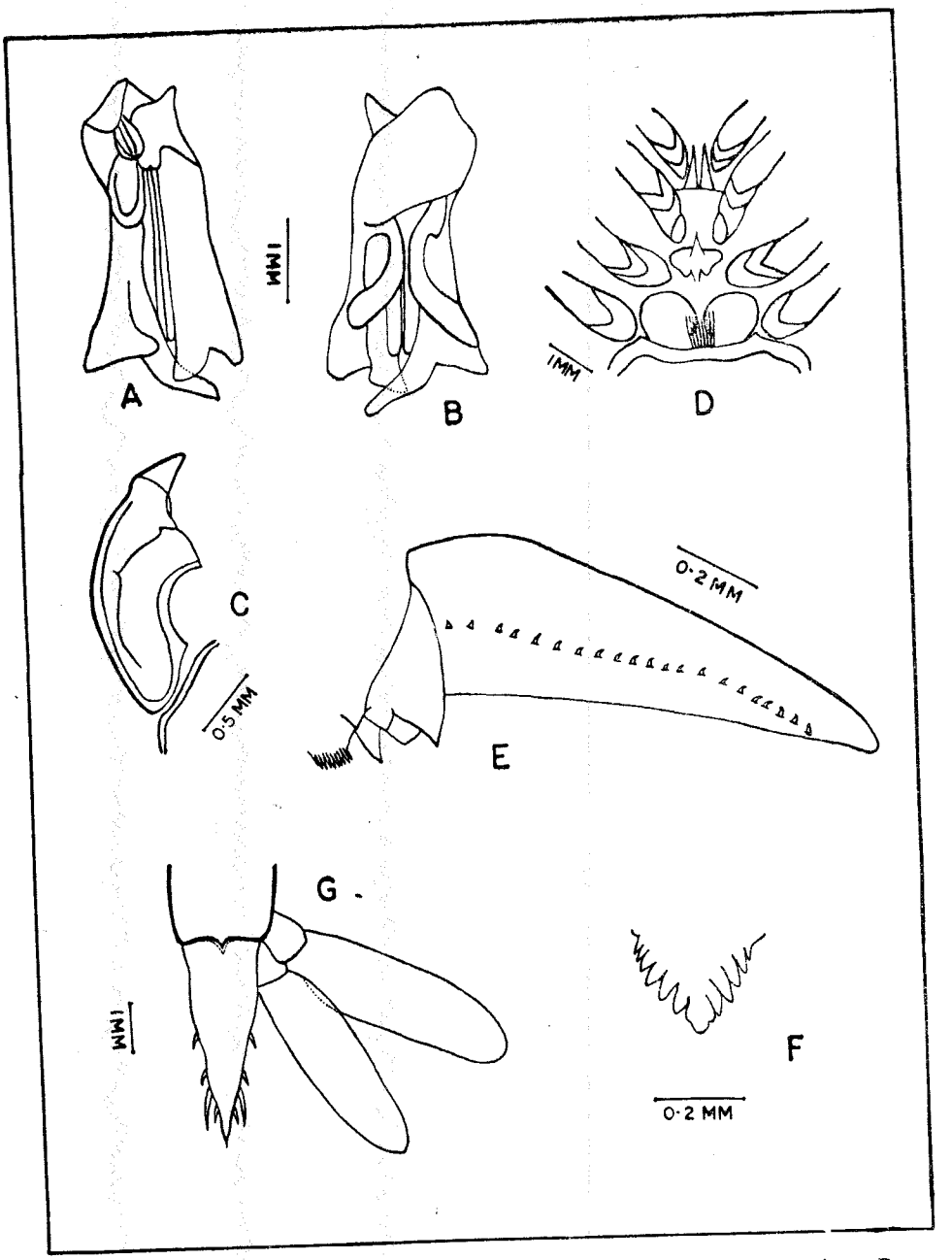


FIG. 1, A-G. *Metapenaeopsis borradaili* (de Man). A, Petasma, dorsal view ; B, same, ventral view ; C, appendix masculina, dorsal view ; D, thelycum, female of 10 mm. carapace length ; E, cardiac plate ; F, prepyloric ossicle ; G, telson and uropod (on right side only).

pelago and the specimens described earlier by de Man (1911) from Siboga Expedition localities and Dall from Murray Island, Torres Strait, are discussed.

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